NASA Technical Paper 1335

Variability of Annoyance Response Due to Aircraft Noise

Thomas K. Dempsey and Jimmy M. Cawthorn

MARCH 1979

NASA

NASA Technical Paper 1335

Variability of Annoyance Response Due to Aircraft Noise

Thomas K. Dempsey and Jimmy M. Cawthorn
Langley Research Center
Hampton, Virginia

National Aeronautics
and Space Administration

**Scientific and Technical
Information Office**

1979

SUMMARY

An investigation was conducted to study the variability in the response of subjects participating in noise experiments. This paper presents a description of a model developed to include this variability which incorporates an "aircraft-noise adaptation level" or an annoyance calibration for each individual. People from the Hampton, Virginia, area and the John F. Kennedy International Airport area of New York City participated as test subjects. As expected, there was some variation of annoyance responses of people within each subject group, as well as variation of the responses between groups. The New York subjects rated a given aircraft noise as more annoying than did the Virginia subjects.

The results indicate that the use of an aircraft-noise adaptation level improved prediction accuracy of annoyance responses. Incorporation of a person's aircraft-noise adaptation level in these predictions significantly reduced the within-group variation and at the same time appeared to account for between-group variation. However, the aircraft-noise adaptation levels could not be predicted by either attitude-personality indices collected from each individual or aircraft-street noise impact information collected in the vicinity of a person's residence. In this investigation, no evidence was found which indicated that annoyance responses varied as a function of the noise environment of the subject's residence. Thus, the group differences in annoyance responses (and aircraft-noise adaptation levels) exhibited in the test results were traced to the selection of subjects from different geographic areas rather than from different aircraft-noise exposure areas.

INTRODUCTION

Air transportation and the associated noise impact in airport communities has resulted in concern and often annoyance of residents about this form of environmental intrusion. In order to determine the aspects of aircraft noise that cause annoyance, laboratory studies are often utilized to assess the importance of various physical aspects of noise on subjective response. Associated with these laboratory studies is a large variation in annoyance responses provided by different people to even a single aircraft noise. This problem of response variation is amplified when a variety of aircraft noises are considered or the effects of aircraft noise are obtained through community investigations or surveys. As a consequence, the problem of response variability makes it difficult to provide accurate information for comparison of the relative annoyance of various aircraft, or for evaluation of the benefits of various optimization schemes for the reduction of aircraft noise through aircraft-airport operations.

A recent review of laboratory studies and community-survey investigations, as given in reference 1, has demonstrated that these studies considered only the noise stimuli as a source of variation in annoyance responses. The present investigation has expanded this approach through the development of a model based on a series of studies which consider the importance of various environmental and psychological factors which may also influence the individual's annoyance responses. Central to this approach is the calibration of each subject through a procedure termed "aircraft-noise adaptation level." The aircraft-noise adaptation level is defined as a noise level which evokes an annoyance response from a subject at least 50 percent of the time. The purposes of this paper are (1) to describe an aircraft-noise adaptation model currently being developed to account for the subjective response variation in laboratory or survey research, and (2) to present results of several laboratory investigations and a noise survey conducted for evaluation of the model.

SYMBOLS AND ABBREVIATIONS

The following symbols and abbreviations have been used in this report. Additional descriptive information concerning frequency weightings and computational procedures for noise scales and indices can be found in references 4 and 5.

AA	aircraft-noise adaptation level (frame of reference, individual's calibration level)
AN	aircraft-noise exposure
AR	aircraft annoyance response
AT	aircraft attitudes
L_A	A-weighted sound pressure level
L_x	value of L_A equalled or exceeded x percent of the time
NEF	noise exposure forecast
NS	noise sensitivity
NY_{LRC}	New York residents tested at Langley Research Center
NY_{CU}	New York residents tested at Columbia University
ST_N	street-noise level
TS	test stimuli (aircraft noise)
VA_{LRC}	Virginia residents tested at Langley Research Center

BACKGROUND INFORMATION AND MODEL DEVELOPMENT

Traditional Aircraft-Noise Studies

Traditional laboratory studies and community-survey investigations of the effects of aircraft noise on people have used the type of experimental paradigm displayed in figure 1. Through use of an annoyance scale as shown in the right of the figure, a person indicates an annoyance response to various aircraft noises. The researcher then relates the strength of annoyance response to physical measurements of the aircraft. A problem of this technique is that annoyance responses of different people vary widely even for the same aircraft noise. In community surveys, for example, only 25 to 50 percent of the annoyance-response variability has been accounted for by the physical measurements (ref. 2).

Aircraft-Noise Adaptation Model

The problem of subjective response variability can be approached by using the aircraft-noise adaptation paradigm displayed schematically in figure 2. This approach represents a modification of classical psychophysics theory as discussed in reference 3 in that a specific annoyance response is proposed to be a function of the interpretation of an aircraft noise by a person relative to his frame of reference. This frame of reference is defined as the aircraft-noise adaptation level which represents the transfer function (gain, sensitivity, modulation, etc.) between aircraft noises and annoyance responses for each subject.

Components of the Model

Figure 3 displays the initial assumptions as to the determiners of a person's aircraft adaptation level. Both physical and psychological factors are considered to influence the person's frame of reference regarding aircraft noise. The primary physical factors include the aircraft-noise exposure in the area in which the person resides, the street noise of the immediate neighborhood, environmental factors such as vibration, temperature, and so forth, and the characteristics peculiar to the geographical location of subjects. Concerning geographical location, a number of investigations have been conducted on residents of airport communities as well as on people from nonaircraft-noise impacted areas (see refs. 2, 4, and 6 to 8) with a lack of consistent conclusions as to the effect of aircraft noise on annoyance responses. Because of the experimental design of these studies, it is not clear whether this lack of consistency is due to selecting subjects from residential areas of varying aircraft-noise impact or simply from different geographical locations. Therefore, research is needed to separate the effects of geographical location and amount of aircraft-noise exposure on annoyance responses.

The psychological determiners of aircraft-noise adaptation include attitudes toward aircraft, noise sensitivity, environmental sensitivity, and various personality factors. Each of these potential psychological determiners of aircraft adaptation level was investigated within the present series of studies and is discussed in this paper. However, the important point is that each of the physical or psychological factors represents a potential source for explanation of annoyance-response variation in the prediction of annoyance.

The relationship between model components of annoyance response displayed in figure 3 can be mathematically expressed as

$$AR = f_1(TS,AA) \tag{1}$$

where

$$AA = f_2(TS,AN,ST_N,AT,NS,. . .) \tag{2}$$

The current studies have provided initial information for formulation of equations (1) and (2) based on empirical results. Due to the difficulty associated with definition and measurement of an individual's aircraft-noise adaptation level, a two-step approach was used for analysis of the concept. The first step involved obtaining a measurement of annoyance responses from each person relative to a standard noise in a fashion similar to calibration of physical equipment. The second step involved obtaining an estimation of the aircraft-noise adaptation level through the collection of various physical and psychological information shown in figure 3. With information from both measurement and estimation, a workable definition of aircraft-noise adaptation should evolve.

Refinement of Objectives

The general objective of this study was to account for the variability in subjective responses of different people to aircraft noise and thus validate an aircraft-noise adaptation model. In order to study this response variability, two separate but similar laboratory investigations were conducted which allowed for selection of subjects from different geographical locations as well as different aircraft-noise impact areas. The initial study was conducted at Langley Research Center with the majority of subjects being selected from the general population of Virginia residents. The experimental phase of the second investigation was conducted by Eugene Galanter of the Psychophysics Laboratory of Columbia University. Subjects for this study were residents of New York and were selected from residential areas of varying aircraft and street-noise impact around John F. Kennedy International Airport. Glynn D. Coates of Old Dominion University assisted in data analyses of both studies.

Similar detailed information was collected from each participant in the study at Langley and Columbia. The information collected included annoyance reactions to a wide range of aircraft noises, measured aircraft-noise adaptation levels, and various attitude-personality measures. In addition, for people tested at Columbia, a noise-measurement survey was conducted to describe street-noise exposure that characterized each person's residence, the residential site having been selected to be within a predetermined aircraft-noise impact area. These different sources of information were combined to determine the predictability of annoyance-response variability between people and groups of people.

To accomplish the general objective of the study, several subobjectives were undertaken, and they are presented as follows:

(1) To describe the annoyance-response variability between and within groups of subjects to aircraft noise.

(2) To assess the ability to measure an aircraft-noise adaptation level for an individual.

(3) To determine the value of aircraft-noise adaptation level in improving the prediction accuracy of annoyance responses.

(4) To assess the relative importance of the various physical and psychological factors associated with an individual's aircraft-noise adaptation level.

(5) To determine the importance of the environmental factors due to aircraft- and street-noise exposure and geographical location of subjects on laboratory annoyance responses.

FACILITIES AND METHODS

Test Facilities

Monophonic recordings of various aircraft noises were tape recorded and presented to subjects in laboratories at both the Langley Research Center and Columbia University. Since results from the two laboratories needed to be compared for model development, an effort was made to present identical aircraft noises in the two laboratories. Although some tape hiss was audible on the original recordings, an acoustic filter with a rolloff at 6000 Hz was used to reduce the extraneous noises at both laboratories. The Langley facility used was the exterior effects room (fig. 4) of the Aircraft-Noise Reduction Laboratory. Six overhead loudspeakers were used for presentation of noise to the subjects. The Columbia facility used was the Psychophysics Laboratory pictured in figure 5. Four loudspeakers were used for presentation of noise to the subjects. The noises presented at the two laboratories were essentially identical as demonstrated by correlation coefficients computed between the same sequence of noises measured at the two facilities. The average of the correlation coefficients computed for the different rating scales was 0.92, indicating that a very strong similarity existed between the same noise reproduced and measured at the two facilities.

Subjects

A total of 253 subjects participated in the study at the 2 laboratories. Eighty residents of Virginia (VA_{LRC}) and 29 residents of New York (NY_{LRC}) were tested at Langley Research Center, and 144 residents of New York (NY_{CU}) were tested at Columbia University. Table I indicates that these participants varied in age, sex, and hearing ability, as well as in location of residence. The 80 residents of Virginia (VA_{LRC}) represented subjects tested for the initial development of the model and were required to have no worse than 20 dB of standard normal hearing (ref. 9). The 29 residents of New York (NY_{LRC}) participated in the study at Langley because of their interests in aircraft-noise problems. The 144 residents of New York (NY_{CU}) were purposely not required to be within any standard hearing limits. The hearing constraint was not imposed so that some information could be obtained as to the relative importance of hearing ability to annoyance ratings. The hearing ability of the NY_{LRC} or NY_{CU} groups was "normal" for their age as defined by the criteria of reference 10.

Noise Survey

The laboratory experiment conducted at Columbia University used subjects from residential areas that varied in the degree of aircraft-noise and street-noise exposure. The experimental design used for selection of residential sites and subjects is displayed in figure 6. The NEF contours were constructed on a map of the John F. Kennedy International Airport area and were used to define the degree of aircraft-noise exposure. Community sites located within an area in which the NEF is greater than 40, between 30 and 40, or less than 30 were defined as high, medium, or low aircraft-noise exposure areas, respectively.

For each level of aircraft-noise impact, three levels of street-noise impact were selected. A street-noise survey, as described in appendix A, was used to select the street-noise impact areas within the aircraft-noise impact areas. This survey was conducted so as not to include aircraft noise. The street-noise survey resulted in definition of community areas with L_{eq} measurements larger than 61, between 57 and 61, and below 57 as high, medium, and low, respectively. As is displayed in figure 6, this factorial combination of aircraft and street noise resulted in nine noise impact areas. However, in order to reduce problems of sample bias due to socioeconomic information, and so forth, two community sites were actually selected for each of the nine cells of figure 6. Consequently, a total of 8 subjects were selected from each of 18 community sites for the laboratory study.

Test Procedure

The test procedure used at the two laboratories was essentially identical. Consequently, the discussion that follows, except where noted, applies to either laboratory. An average of eight subjects participated in the study during each test session which lasted approximately 4 hours. Each subject was audiometrically screened prior to participating in the study. At the start of testing, each subject completed consent forms (see appendix B) and was briefed concerning the series of activities for the study. Table II lists the activities and the approximate time duration of each activity.

Measured aircraft-noise adaptation level.- The initial portion of the test was used to obtain the measured aircraft-noise adaptation level for each subject. The instructions for the task are reproduced in appendix B. In this task, each subject used the method of constant stimuli to evaluate noises of the American National Standards Institute (ANSI) (ref. 11) of 15-second duration, which ranged in A-weighted sound-pressure level from 65- to 95-dB increments (giving a total of seven noise levels). As shown in figure 7, a subject was presented a particular ANSI noise and was asked whether the noise was "annoying" or "not annoying." Successive noises were presented and similar responses were obtained for each noise. The 7 noise levels were randomized (without replacement) a total of 4 times so that each subject evaluated a total of 28 noises during this period of testing.

Figure 8 displays the type of analysis that was completed in order to obtain the measured aircraft-noise adaptation level for each subject. The figure indicates the relationship of annoyance to noise level for a given subject. The noise level evoking an annoyance response 50 percent of the time was then taken as the subject's aircraft-noise adaptation level. For the example in figure 8, the person's measured aircraft-noise adaptation level was an A-level of 75 dB.

Postthreshold testing was identical (except for noise-presentation randomizations) to prethreshold testing. The reason for postthreshold testing was to assess the influence of the aircraft noises that occurred within the experiment upon a person's aircraft-noise adaptation level.

Aircraft-noise stimuli.- The aircraft noises that each subject evaluated are shown in the experimental design (fig. 9). The aircraft noises varied in (were factorial combinations of) aircraft type, noise level, and aircraft operation for a total of 56 different stimuli which were randomized for each group of subjects. All noises were recorded at locations near the noise-certification measurement points established by the Federal Aviation Administration (FAR-36) for takeoff and approach operations. A detailed description of the stimuli is reported in reference 12.

In this portion of the experiment, annoyance judgments of various aircraft noises were obtained. The instructions for the task are reproduced in appendix B. The category scale which subjects used to evaluate each noise was unipolar, continuous, and contained nine scalar points or demarcations.

Attitude tests.- During two different activity periods, each subject was requested to supply various attitude information through a series of paper and pencil tasks. This information was collected primarily to determine the relative importance of various psychological factors for the construction of an individual's aircraft-noise adaptation level. The tests of the first activity period were directed at demographics, aircraft attitudes, noise sensitivity, environmental sensitivity (see appendix C), perception preferences (Myers-Briggs type indicator), and self-concept information (adjective checklist). The tests of the second activity period were directed at information about the individual's anxiety level (state-trait anxiety inventory) and perceptual functions (group-embedded-figures test). The latter four tests are discussed in reference 13.

RESULTS AND DISCUSSION

This section provides a discussion of the results related to the five subobjectives listed previously in the section entitled "Refinement of Objectives." The first four objectives were addressed by both the study at the Langley

Research Center and the experiment at Columbia University, whereas information for the last objective was obtained through comparison of the results from the two laboratories. Since there is an overlap of objectives between the studies, this section is organized in terms of objectives rather than separate studies. The implication of these results for the aircraft-noise adaptation model is briefly discussed.

Overall Aircraft-Noise Effects

The initial objective of the study was to provide a description of the aircraft-noise annoyance-response variability between and within groups of subjects. Three similar analyses of variance were computed in order to summarize these results. The basic analysis of variance ($7 \times 2 \times 4$) consisted of factorial combinations of the seven airplane types for two operations and four noise levels with repeated measurements on all dimensions. Tables III, IV, and V provide summaries of the analyses that were computed separately for the three groups of subjects (VA_{LRC}, NY_{LRC}, and NY_{CU}), respectively. Each table also has a column of percent of variance explained by each factor. The entries in this column are derived from a partitioning of expected mean squares for a mixed model with subjects considered a random factor. (See ref. 14.) The separate analyses were computed because there were several factors that varied between the subject groups in addition to location of residence. Note that the analysis of variance was more extensive for the subjects tested at Columbia University (table V) than for the other two subject groups. This extension was specifically designed to address the question of whether or not aircraft-noise and street-noise impact of a residential area influence the annoyance responses of people.

The results of tables III, IV, and V indicate that the effects of aircraft type, operations and noise levels, and most of their interactions were significant for each group of subjects. The relative importance of these effects (and their interactions) should be considered prior to a discussion of the implications of the results. The column of percent variance explained by each factor provides perspective information for comparison of the importance of each factor. An initial consideration of these columns indicates that 62.9, 69.1, and 59.4 percent of response variation is accounted for by physical main effects (and the interactions) for the VA_{LRC}, NY_{LRC}, and NY_{CU} subject groups, respectively. (The value of 62.9 is derived by summing explained variances of 0.29, 0.65, 59.18, . . ., 0.37, ...) Consequently, for the analysis of variance designs of tables III, IV, and V the between-subject variability within each subject group is 37.1, 30.9, and 40.6 for VA_{LRC}, NY_{LRC}, and NY_{CU} subject groups, respectively. These results indicate that despite the importance of the physical factors in accounting for response variation, there is a sizable amount of variance attributable to subject differences within each group. These percent-variance estimates can be considered to be error for the present study since they reduce the prediction accuracy due to physical factors. Additional consideration of the columns of percent-explained variance indicates that noise level alone was the single most important predictor of annoyance responses and accounted for the majority of explained variance. Further, aircraft type and type of operations are of minimal value in predicting annoyance responses since the percent of variance explained by these factors is small.

The single important effect of noise level from tables III, IV, and V is shown in figure 10. This figure displays the annoyance responses that occurred for each group of subjects (NY_{CU}, NY_{LRC}, and VA_{LRC}) as a function of A-weighted sound pressure level. These results indicate there was a monotonic increase of annoyance responses with noise level for each group of subjects. More important, a series of t-tests between the slopes of the curves in figure 10 indicated the rate of change of annoyance with increases of noise level was similar (no significant differences) for the three groups of subjects. However, there was an absolute difference in annoyance ratings assigned to aircraft noises by the different subject groups reflective of between-group variability. For example, the NY_{LRC} subjects systematically evaluated the aircraft noises as more annoying than the NY_{CU} subjects, and this latter group evaluated the aircraft noises as more annoying than the VA_{LRC} subjects.

The last two results are of particular importance since the lack of slope differences between groups combined with the absolute difference of annoyance between groups would logically occur if the average aircraft-noise adaptation level of one group was lower than that for the other groups. In other words, the lack of slope difference between groups indicates a similar reaction process to aircraft noise, whereas the absolute annoyance difference between groups seems to reflect the absence of a universal aircraft-noise adaptation level. Consequently, these last two results offer direct support to the hypotheses that aircraft-noise adaptation level is of possible significance.

Aircraft-Noise Adaptation Levels

The second objective was to assess the ability to measure an aircraft-noise adaptation level for an individual. In a previous section entitled "Facilities and Methods" adaptation level is described as the lowest noise level at which the subject was annoyed 50 percent of the time. The aircraft-noise adaptation levels were determined for each subject, and the trends of these values are shown in figures 11 to 14. Figure 11 indicates the cumulative percent of each subject group (NY_{CU}, NY_{LRC}, and VA_{LRC}) that achieved their aircraft-noise adaptation level (means of prethreshold and postthreshold measurements) for a given noise level. For example, the figure shows that 40 percent of the NY_{LRC} subjects had an adaptation level of 73 dB, whereas the 40-percent level for the NY_{CU} subjects was 76 dB and the 40-percent level for the VA_{LRC} subjects was 79 dB. These results indicate that an individual's aircraft-noise adaptation level can be measured.

Figures 12 to 14 represent a division of the data of figure 11 into adaptation levels for prethreshold and postthreshold testing as a function of noise level for each group of subjects. These figures indicate that adaptation levels varied as a function of the following: (1) geographical location; the New York subjects (NY_{CU} and NY_{LRC}) displayed lower aircraft-noise adaptation levels (greater sensitivity to noise) than Virginia subjects (VA_{LRC}); (2) subjects within a geographical location; there was a variability of adaptation levels within each subject population; and (3) testing period; there was a decrease of measured adaptation level for a subject from prethreshold to postthreshold testing within each subject group.

Annoyance-Response Variation

The third objective was to determine the ability to improve the prediction accuracy of annoyance responses through considering each participant's aircraft-noise adaptation level. Consequently, this objective involves combining the information from the discussions of objectives (1) and (2). The discussion of the first objective provided information that subjective responses varied within, as well as between, subject groups. Thus, the accuracy of the annoyance-response predictions could be improved if incorporating the aircraft-noise adaptation of an individual in these predictions served to reduce either type of response variability.

Within-group response variation.- A series of correlation coefficients (and, consequently, explained variance r^2) were computed between annoyance ratings and noise to determine if inclusion of an individual's aircraft-noise adaptation level improved the annoyance-response predictions within groups of subjects. The general applicability of these results were maximized by computing different correlation coefficients based on a factorial combination of the following: (1) rating scales of noise, (2) mathematical relationships of aircraft noise (TS) and an individual's aircraft-noise adaptation level (AA), and (3) psychophysical functions. Further, to allow direct interpretation of the explained variance of these correlations with explained variances of tables III, IV, and V, the correlations were based on individual subject's response data rather than means of the response data for subject groups.

Traditional subjective response studies considered annoyance responses to be expressed by the equation

$$AR = a_1 + b_1(TS) \tag{3}$$

In the present investigation, the computed correlation coefficients indicated that annoyance responses for each group of subjects were most accurately predicted with the linear equation

$$AR = a_2 + b_2\left(TS - \frac{1}{2} AA\right) \tag{4}$$

where TS and AA are expressed in units of L_A and a and b are constants. (The values of the prediction coefficients are discussed later in the paper.) There was an increase of 7 percent in explained variance attributable to the inclusion of an individual's aircraft-noise adaptation level in the predictive equation of annoyance within each group. The 7-percent increase occurred between the correlation which considered TS alone and that for $\left(TS - \frac{1}{2} AA\right)$ for each group of subjects. This 7 percent of explained variance increases the amount of useful explained variance from tables III, IV, and V and at the same time reduces the amount of variance considered as error that had been attributed to subjects within groups. The average within-subject-group error variance (mean values of 37.1, 30.9, and 40.6 from tables II, IV, and V, respectively) was 36.2 percent. Consequently, the use of an individual's aircraft-noise adaptation level reduces error variance by approximately 19 percent. (That is, 7 ÷ 36.2 = 19 percent.)

Between-group response variation.- This section addresses the improvement of annoyance-response predictions between groups of subjects through consideration of adaptation level of individuals. Alternatively stated, the question is whether the group differences of aircraft-noise adaptation level shown in figure 11 account for the group differences of annoyance responses shown in figure 10. The New York (NY_{LRC} and NY_{CU}) subjects, on the average, displayed lower aircraft-noise adaptation levels than the Virginia (VA_{LRC}) subjects. In order to explain this difference, it is assumed that the aircraft-noise adaptation levels of the subject groups are merely extreme cases of a continuous distribution (of aircraft-noise adaptation level) rather than cases of uniquely different populations. Since it is not clear whether the assumption is clearly justified, the analysis described to account for population differences should be considered tentative pending collection of more comprehensive data regarding the distribution of aircraft-noise adaptation levels for different populations.

The analyses which address this concept involved combining the annoyance responses for the three subject groups within a single predictive equation. The factors considered as predictors for these analyses were the same as those obtained from the previous section which addressed within-group response variability. The predictive equation that resulted from these analyses can be expressed as follows:

$$AR = -3.43 + 0.18\left(TS - \frac{1}{2}\,AA\right) \tag{5}$$

This equation was then used as a basis for addressing between-group response variations as shown in figure 15. This figure displays the actual annoyance responses of NY_{CU} and VA_{LRC} subject groups (data of fig. 10), as well as adjusted responses for VA_{LRC} subjects, as a function of A-weighted sound pressure level. The graph of adjusted VA_{LRC} subjects displayed an average aircraft-noise adaptation level of 4 dB higher than that of the NY_{CU} subjects. For the task of equating the responses of the two groups, the noises for VA_{LRC} subjects must be decreased 2 dB. (From eq. (5) a difference of 4 dB in aircraft-noise adaptation level equates to a stimulus-level difference of 2 dB.) These assumptions account for the difference between groups.

Equation (5) was used to predict the annoyance responses separately for each group of subjects in order to determine if combining the response data (to account for between-group differences) would reduce the amount of explained variance (7 percent) that had been added to the prediction of annoyance within groups of subjects. These results indicated that the annoyance-response predictions were identical for each group if based on equation (5) or a similar function for each separate group. The implication of these findings is that accounting for between-group response variability does not alter the explanation of within-group response variability. In summary, therefore, equation (5) accounts for a large part of response variation of subjects within groups as well as response variation between groups of subjects.

An additional implication can be derived from equation (5) as to the degree of effect of a person's aircraft-noise adaptation level on his annoyance response. Figure 16 displays the stimulus-level increase required for constant annoyance rating as a function of aircraft-noise adaptation level (based on eq. (5)). The graph can be understood through considering the two extremes: A person with a low aircraft-noise adaptation level of 65 dB had a high noise sensitivity and required a 0-dB stimulus increase for a certain judged annoyance response. On the other hand, a person with a high aircraft adaptation level of 95 dB had a low noise sensitivity and required a 15-dB stimulus increase for a similar annoyance response. If a specific stimulus was evaluated on the subjective rating scale as 2 by a person with a low adaptation level, that same stimulus had to be increased by 15 dB in noise level to receive an equal subjective evaluation by a person with a high adaptation level. These results suggest the following: (1) aircraft annoyance varies considerably as a function of a person's aircraft-noise adaptation level; for example, depending on the noise sensitivity of the test subjects, equal annoyance responses can be obtained from two people to aircraft noises separated by as much as 15 dB in level; and (2) the development of noise criteria for different geographical locations of airport communities should account for the noise sensitivity of community residents. A subsequent section addresses whether the variation in aircraft-noise adaptation levels and annoyance responses are due to people residing in different aircraft-noise impact areas or simply different geographical locations.

Prediction of Aircraft-Noise Adaptation

The fourth objective was to assess the relative importance of the various physical and psychological factors associated with an individual's aircraft-noise adaptation level. To address this question, stepwise multiple correlations were computed to predict the aircraft-noise adaptation levels of participants in the two laboratory studies. Tables VI and VII provide the results of these analyses for the participants of the study at Langley Research Center and Columbia University, respectively. In addition to the multiple-correlation information, the column located at the extreme right-hand side of tables VI and VII contains simple correlation coefficients between successive indices and aircraft-noise adaptation levels. The multiple correlations for the study at Langley Research Center were based on the various psychological indices collected from each participant. Due to the technical and restricted meaning of the indices, an exact definition of the indices should be obtained from references 10 to 13. Further, the multiple correlations for the study at Columbia University were based on physical measures of aircraft and street-noise impact of a participant's residence as well as the psychological indices.

A comparison of the results in tables VI and VII indicates that neither attitude-personality indices nor measures of noise exposure (aircraft and street) provide a satisfactory prediction of an individual's aircraft-noise adaptation level. The multiple correlations that result from using the first 15 predictors in each table are sizable (table VI is 0.6857 and table VII is 0.5120). However, since the same 15 predictors were not extracted for the 2 studies, or in approximately the same order, the separate analyses appear to be fitting only error variance. Additional support can be made for the latter statement by considering that extraction of successive factors in either table accounted for only a minimal amount of explained variance, usually less than 1 percent.

Table VII indicates that aircraft- and street-noise impact of a residential area does not influence a person's aircraft-noise adaptation level. Neither measure of noise impact (NEF or L_{eq}) accounted for greater than 1 percent of the variation in aircraft-noise adaptation levels. Consequently, information about these types of noise exposure are of little or no value for the prediction of an individual's aircraft-noise adaptation level.

Effects of Environmental Factors

The last objective of this study was to determine the importance of exposure to the environmental factors of aircraft and street noise and of geographical location on laboratory annoyance responses.

This objective is addressed with the analyses of variance (table V) of responses for the NY_{CU} subjects that were selected from residential areas of varying aircraft- and street-noise exposure. The main effects of aircraft-noise exposure and street-noise exposure were not significant. The annoyance responses associated with these main effects as a function of noise level are shown in figures 17 and 18. These results indicate that subjects display the same absolute increase of annoyance responses to increases of aircraft noise irrespective of the aircraft- and/or street-noise characteristics of their residence. In other words, the amount of aircraft- or street-noise exposure of a person's residential location does not influence his sensitivity or annoyance to aircraft noise. Since there is no need to consider people of different noise-exposure areas (aircraft or street) as unique, it would apparently be possible to describe the annoyance responses of people to aircraft-noise levels through the use of a single function, namely, equation (5).

The importance of geographical location of subjects on laboratory annoyance responses is an important question for future research and model development. Earlier analyses indicated that differences of aircraft-noise adaptation level (figs. 10 and 11) exist for subjects selected from different geographical areas. Therefore, the question is whether these group differences of aircraft-noise adaptation level are a function of the amount of aircraft- and/or street-noise exposure of a person's residence or a function of selecting subjects from different geographical areas. Of course, attributing the group differences to selection of subjects from different geographical areas is only a partial answer, the reason being that physical factors not investigated in the present study could be responsible for the group differences. (For example, industrial noise, community noise, etc., which may not be common to the different groups could explain the group differences.) Nevertheless, the preceding results indicated that neither aircraft- nor street-noise exposure of a person's residence affected aircraft-noise adaptation levels. Consequently, these results imply that the group differences can be attributed to the selection of subjects from different geographical areas. This implication, however, should be considered tentative until further research of physical factors is conducted to explore alternative explanations for these group differences.

CONCLUSIONS

A series of studies was conducted to develop an aircraft-noise adaptation model to account for much of the variability in the responses of subjects participating in human response to noise experiments. Specific conclusions from the studies that related directly to the problem of response variability or the aircraft-noise adaptation model and its refinement are given as follows:

1. Annoyance-response variability was documented for different people and groups of people.

2. The noise level of an aircraft was the single most important factor for prediction of annoyance responses to aircraft noise, whereas the type of aircraft or type of aircraft operation are of little or no value for these predictions.

3. Aircraft-noise adaptation levels were measurable and they varied within and between populations as well as from the beginning to the end of the experimental study.

4. Group differences of aircraft-noise adaptation levels varied in a fashion parallel to group differences of annoyance response.

5. Combining information of the aircraft-noise level with an individual's aircraft-noise adaptation level increased the amount of explained variance of annoyance responses within and between groups. These results thus indicated that a person's annoyance response to an aircraft noise is clearly a function of the person's aircraft-noise adaptation level.

6. An individual's aircraft-noise adaptation level is not satisfactorily predictable from either attitude-personality indices or physical-noise measures.

7. Residential aircraft- and street-noise exposure do not affect a person's reaction to aircraft noise.

8. Annoyance-response differences between subject groups were traced to the selection of subjects from different geographical areas.

Langley Research Center
National Aeronautics and Space Administration
Hampton, VA 23665
January 8, 1979

APPENDIX A

STREET-NOISE SURVEY

This appendix addresses the street-noise survey conducted in the vicinity of John F. Kennedy International Airport in order to develop a definition of street-noise impact for selection of residential sites.

Street noise was defined for the noise survey as including all sources of noise impact except those attributable to aircraft in approach or takeoff operations. In order to increase the likelihood that a wide range of street-noise level areas would be selected within each aircraft impact area, a total of 51 sites as displayed in figure A1 were initially screened for noise characteristics. A community site was defined as a circular residential area with a diameter of 0.40 km. These 51 sites were chosen for initial screening based upon projections that the sites would display a wide range in level of street noise due to automobile, truck, or subway traffic patterns and volume. Figure A2 displays the street-noise L_{eq} values obtained during the screening survey (noise measurement is discussed in subsequent sections of this appendix) at these community sites as a function of aircraft impact area. The solid circles of figure A2 indicate the noise levels of the 18 community sites selected for further noise-survey work. The geographical locations of the 18 sites are displayed in figure A3. These 18 community sites were selected from the 51 sites based on a number of constraints. The primary factors used to determine selection of these 18 sites were the street-noise data, zoning ordinances, and general socioeconomic information obtained from residents of the area. The noise environment of each of the 18 community sites is discussed in the following sections.

The survey of street noise at each of the 18 community sites was completed with a commercially produced sound-level meter. A 1.27-cm (1/2-in.) condenser microphone, located 1.12 m from the ground surface, was attached to the meter through appropriate cables. For noise measurements at a particular site the microphone was located on the sidewalk (public property) of a street corner. The selection of a street corner at a particular site was based on convenience of equipment arrangement. The sound-level meter provided direct analysis of the noise environment in terms of A-weighted noise level exceeded for a percent of the sample time, as well as L_{eq} levels for the same sample period. A minimum of four noise samples, each 1000 seconds in duration, were used to characterize the noise environment of each community site. The four noise samples for a particular community site were collected by obtaining a noise sample during each of the following four time periods: (1) 8 a.m. to 12 m., (2) 12 m. to 4 p.m., (3) 7 p.m. to 10 p.m., and (4) 12 p.m. to 6 a.m. Additional noise samples were collected for successive daytime periods, at a particular community site, if the L_{eq} noise level of the time periods differed by 3 dB.

Figures A4 to A21 display the basic noise data and a photograph of the measurement location for each of the 18 community sites. For example, figure A4(a) displays a photograph of the community site from which the noise data of figure A4(b) were obtained. Figure A4(b) displays that the A-weighted noise level exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an

L_{eq} value for the same time, as a function of different sample periods. The survey was conducted to derive a definition of street-noise impact rather than to serve as a comprehensive definition of the statistical nature of street noise at each community site. Therefore, the analyses described in the remainder of this appendix were directed at the definition problem.

A question can be raised at this time as to what is a good rating scale for measurement of street noise within residential communities. This problem is directly analogous to that of deriving or selecting a rating scale for the measurement of aircraft noise. Previous research (for example, refs. 15 and 16) has not resulted in completely consistent information for selection of such a rating scale. However, these studies often select a scale such as L_{eq} since it allows integration of noise energy over time. Some information for determining which rating scale to use can be obtained from the present series of studies by combining the noise-survey data with the subjective response data collected at Columbia University. For example, the stronger the correlation between subjective responses and a particular scale, the greater the likelihood of the appropriateness of that rating scale.

Table AI displays correlation coefficients that were computed between a person's measured aircraft-noise adaptation level and various street-noise rating measures, for different sample periods, as well as different averages (on an energy basis) of the rating measures for different sample periods. The sample periods of columns 5 to 8 represented rating-scale noise averages (on an energy basis) of columns 1 and 2; 1, 2, and 3; 3 and 4; and 1, 2, 3, and 4, respectively. None of the correlations of table AI achieved statistical significance, indicating a lack of reliable relationship between responses and noise measures. The important point from these analyses for rating-scale selection is that any of the rating scales considered could serve equally well as a measure of community noise. Consequently, based on these analyses, and the results of previous investigations, L_{eq} was selected as the rating scale for description of community noise. It should be mentioned that other rating scales such as the Traffic Noise Index and Noise Pollution Level were considered as alternatives to L_{eq}. However, these less frequently used rating scales were not used in the present investigation since they each correlated very highly with L_{eq} for the street-noise samples of the present survey.

The L_{eq} street-noise measurements obtained at the 18 community locations were used to derive a definition of street-noise impact for the experimental design of figure 6. Figure A22 displays these results which represent the noise level in terms of L_{eq} that occurred for each level of street-noise impact as a function of aircraft-noise impact. Each data point of figure A22 represents an average (on an energy basis) of at least four noise samples for each of two community sites selected to represent a cell of figure 6. The differences between L_{eq} values of different street-noise impact levels are relatively small. However, due to the use of L_{eq} as the rating scale and the number of noise samples (for each of two residential locations), these small differences in rating-scale values represent reliable differences.

APPENDIX A

TABLE AI.- RELATIONSHIP BETWEEN SUBJECTIVE RESPONSE AND RESIDENTIAL NOISE IMPACT

[A summary of correlation coefficients computed between a person's measured aircraft-noise adaptation level and various street-noise rating-scale measures of his residential area, for different noise sample periods,* as well as averages (on an energy basis) of rating-scale measures for different sample periods]

Measure	Sample time periods							
	(1)	(2)	(3)	(4)	(5) Day	(6) Awake	(7) Sleep	(8) Overall average
L_1	-0.154	-0.146	-0.113	-0.068	-0.151	-0.147	-0.106	-0.142
L_{10}	-.101	-.090	-.136	-.074	-.099	-.117	-.125	-.111
L_{50}	-.139	-.050	-.179	-.158	-.094	-.101	-.096	-.109
L_{90}	-.196	.006	-.078	-.118	-.106	-.114	-.088	-.120
L_{99}	-.095	.013	-.062	-.090	-.051	-.068	-.070	-.075
L_{eq}	-.086	-.116	-.102	-.118	-.103	-.110	-.104	-.109

*See page 15 for explanation of time periods.

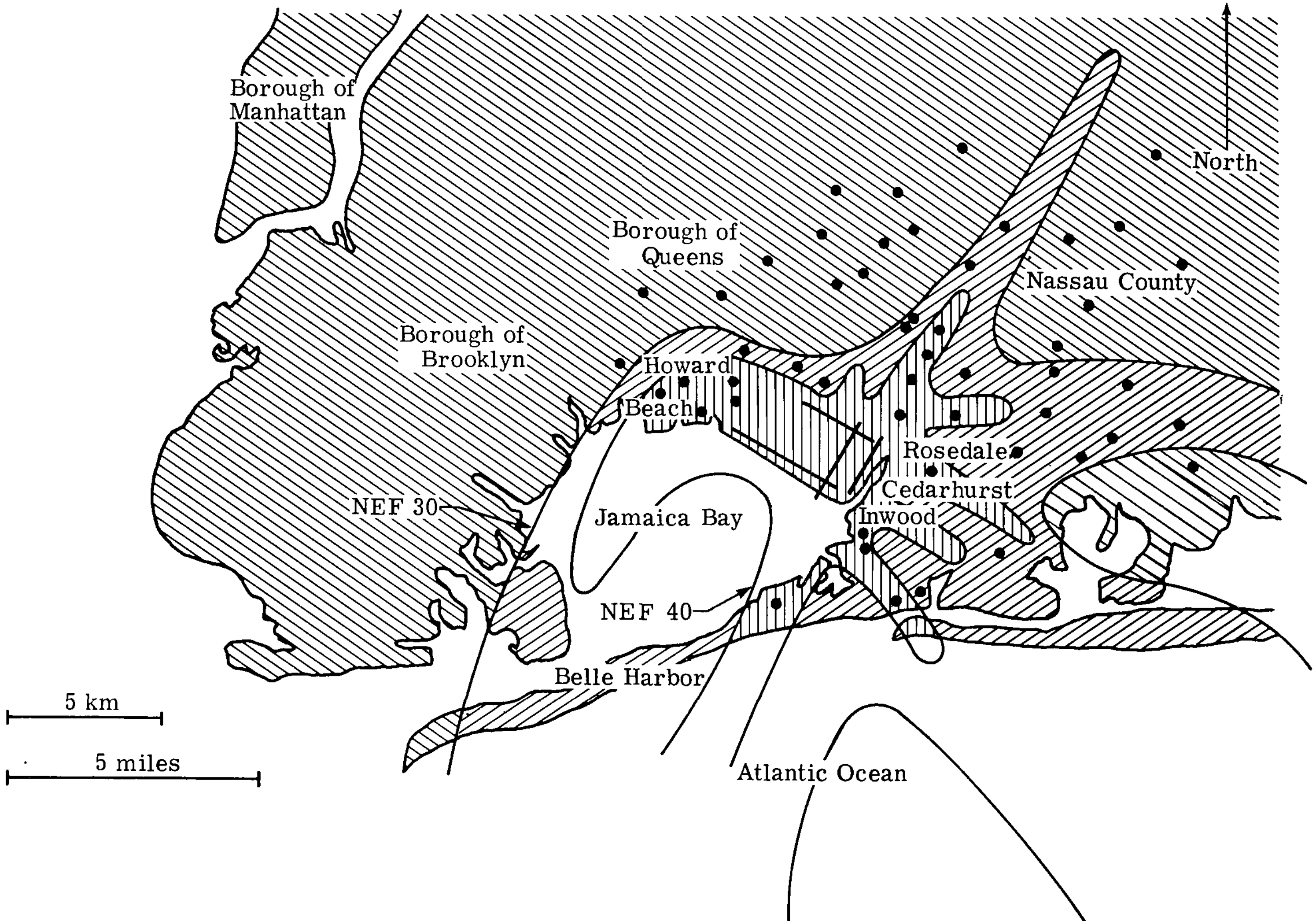


Figure A1.- Map of John F. Kennedy International Airport and vicinity showing locations of the 51 test sites initially screened.

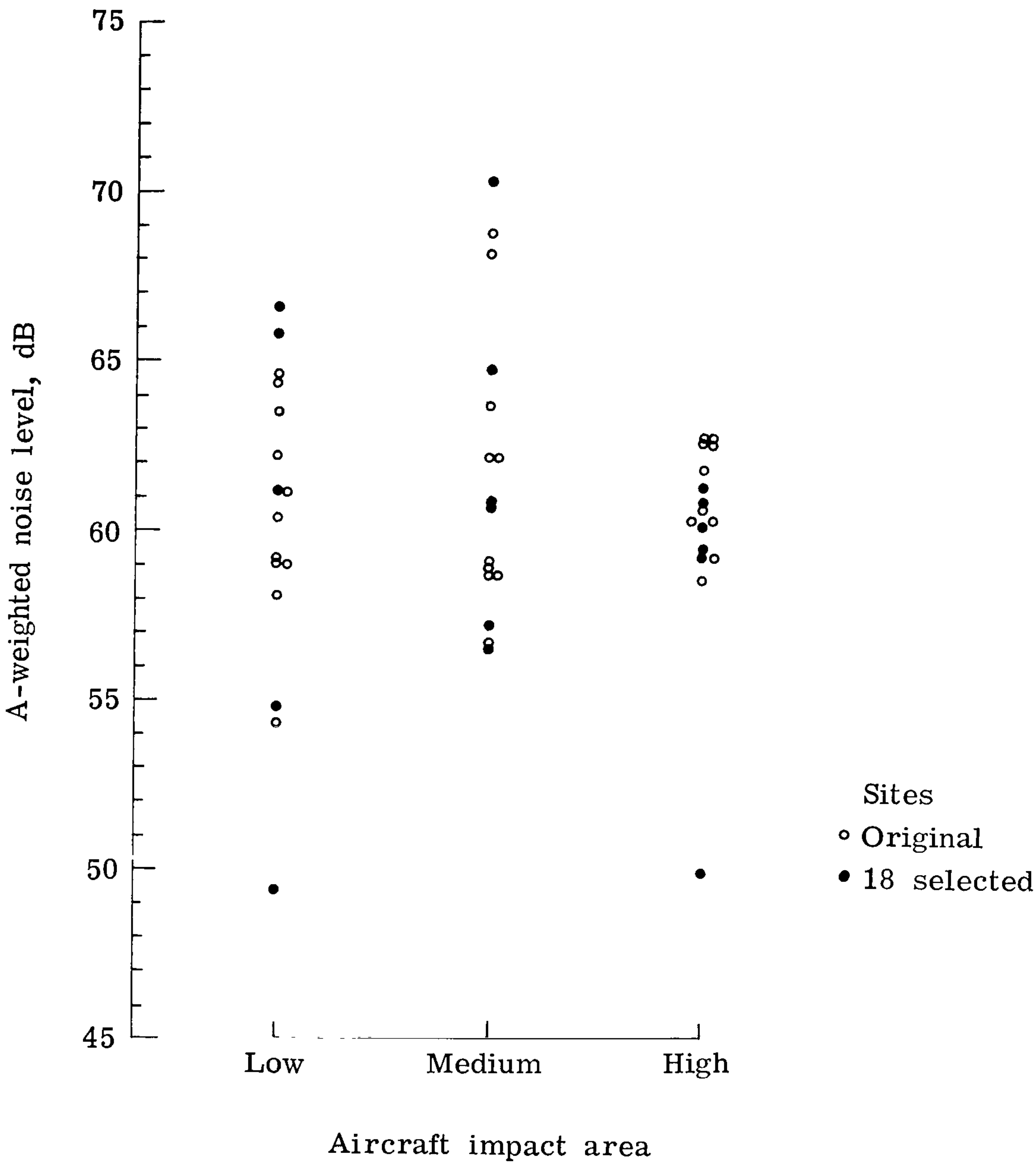


Figure A2.- The noise levels, obtained from the 51 community sites of figure A1, as a function of aircraft impact area. The solid symbols represent sites selected for further noise surveying, whereas the open symbols represent the remaining sites initially screened.

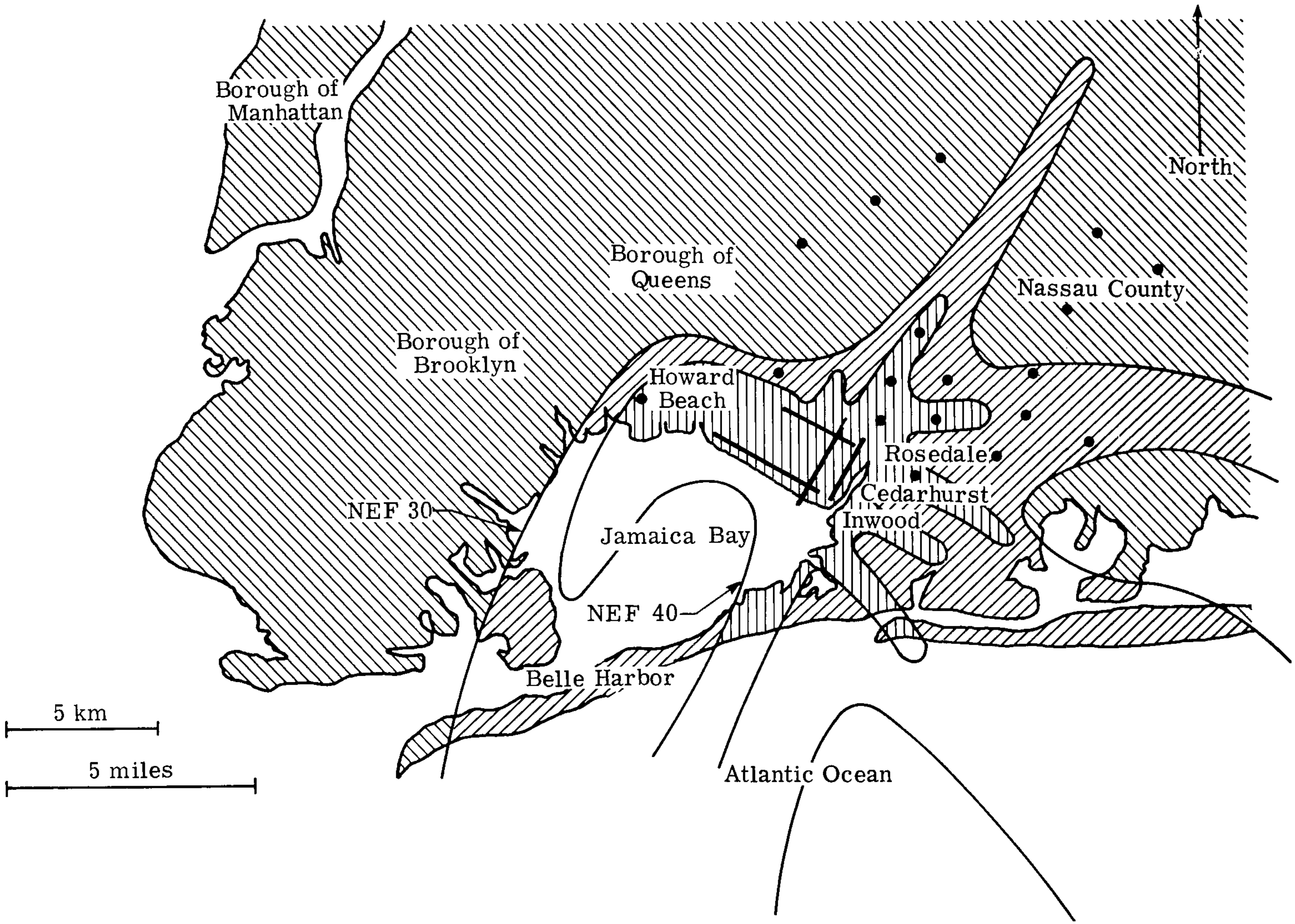
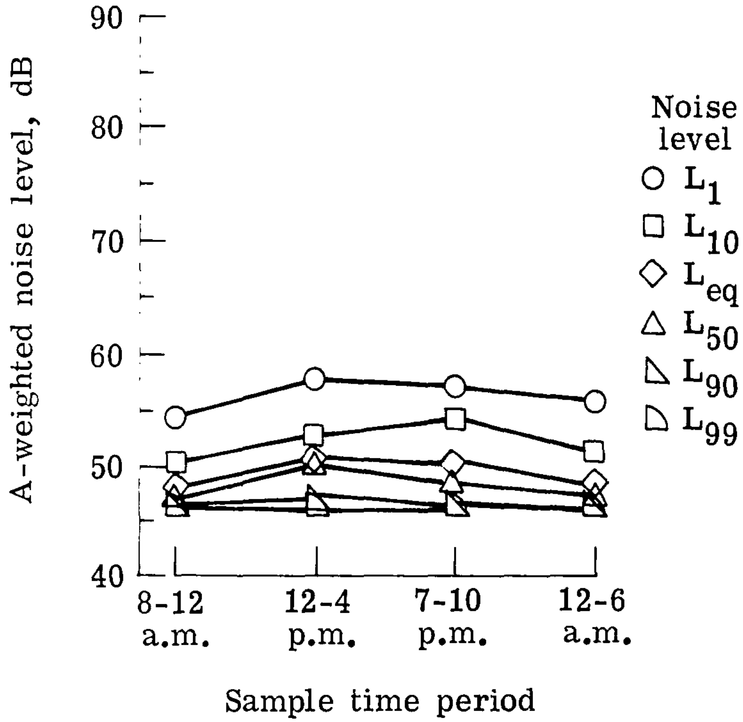


Figure A3.- Map of John F. Kennedy International Airport and vicinity showing locations of the 18 test sites selected for sampling of subjects.

L-79-102

(a) Photograph of community site number 1.

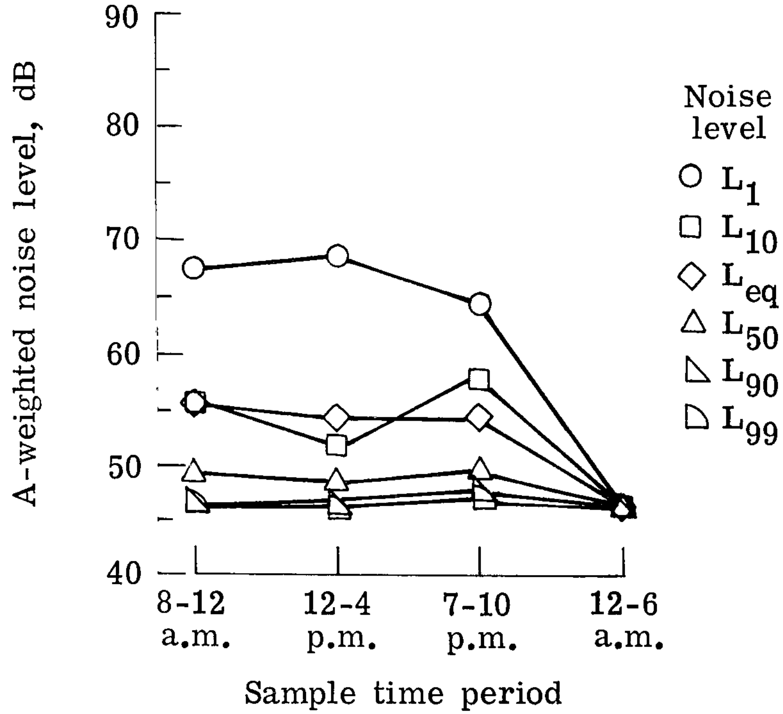


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A4.- Community site number 1 representative of a low-aircraft-noise and low-street-noise impact area located at the intersection of Galway and Mayville Streets, St. Albans, New York.

L-79-103

(a) Photograph of community site number 2.

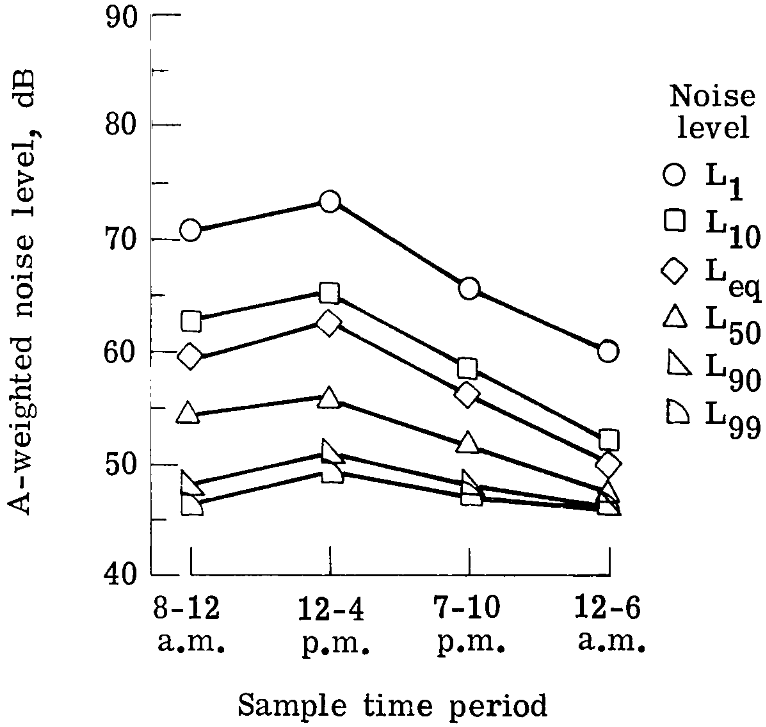


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A5.- Community site number 2 representative of a low-aircraft-noise and low-street-noise impact area located at the intersection of Othello and Carlyle Avenue, North Valley Stream, New York.

L-79-104

(a) Photograph of community site number 3.

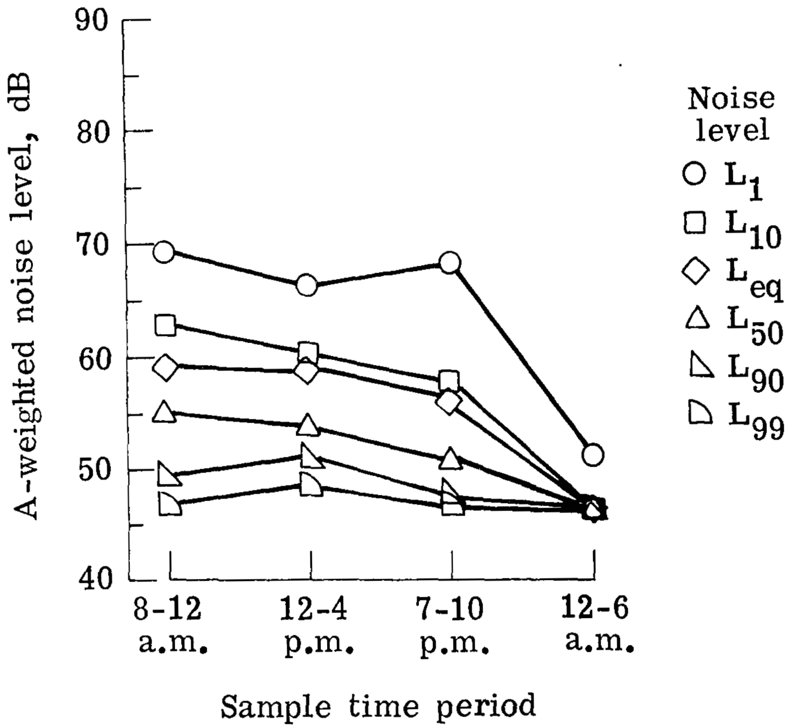


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A6.- Community site number 3 representative of a low-aircraft-noise and medium-street-noise impact area located at the intersection of 81st Avenue and 254th Street, Bellerose, New York.

L-79-105

(a) Photograph of community site number 4.

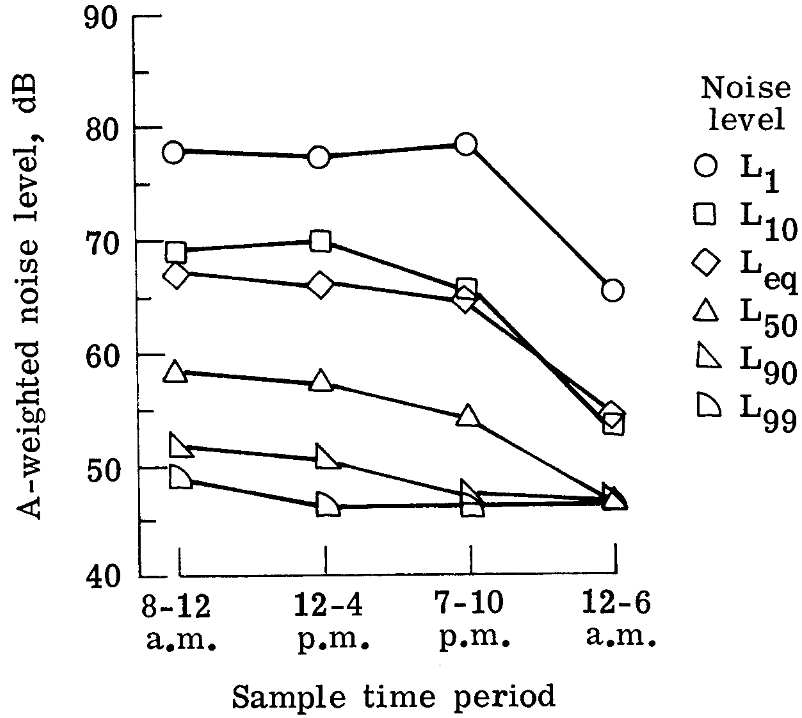


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A7.- Community site number 4 representative of a low-aircraft-noise and medium-street-noise impact area located at the intersection of Oak and Morton Streets, West Hempstead, New York.

L-79-106

(a) Photograph of community site number 5.

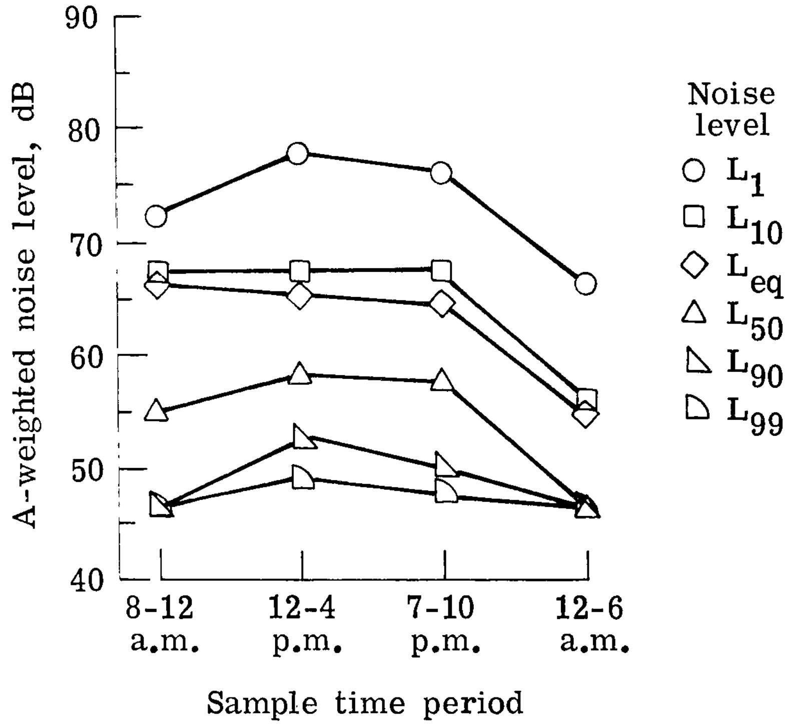


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A8.- Community site number 5 representative of a low-aircraft-noise and high-street-noise impact area located at the intersection of 217th Street and 92nd Avenue, Queens Village, New York.

L-79-107

(a) Photograph of community site number 6.

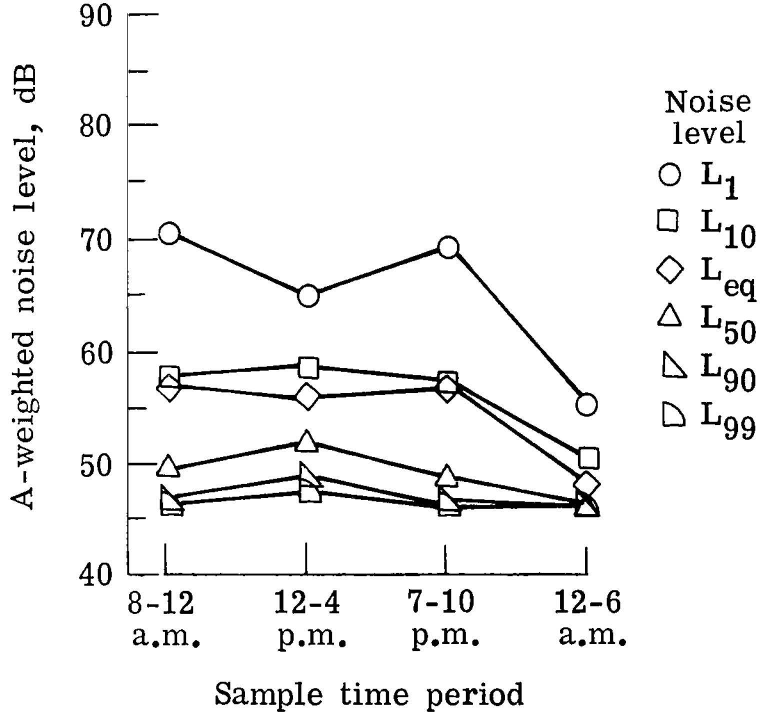


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A9.- Community site number 6 representative of a low-aircraft-noise and high-street-noise impact area located at the intersection of Washington Street and Caroline Avenue, Garden City, New York.

L-79-108

(a) Photograph of community site number 7.

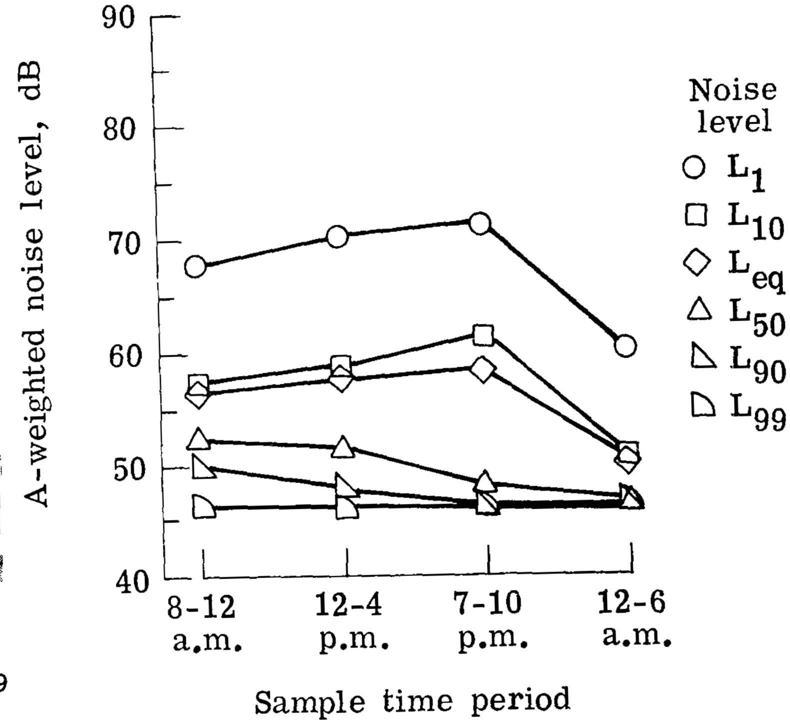


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A10.- Community site number 7 representative of a medium-aircraft-noise and low-street-noise impact area located at the intersection of Hewlett Parkway and Henrietta Sturlane, Hewlett, New York.

L-79-109

(a) Photograph of community site number 8.

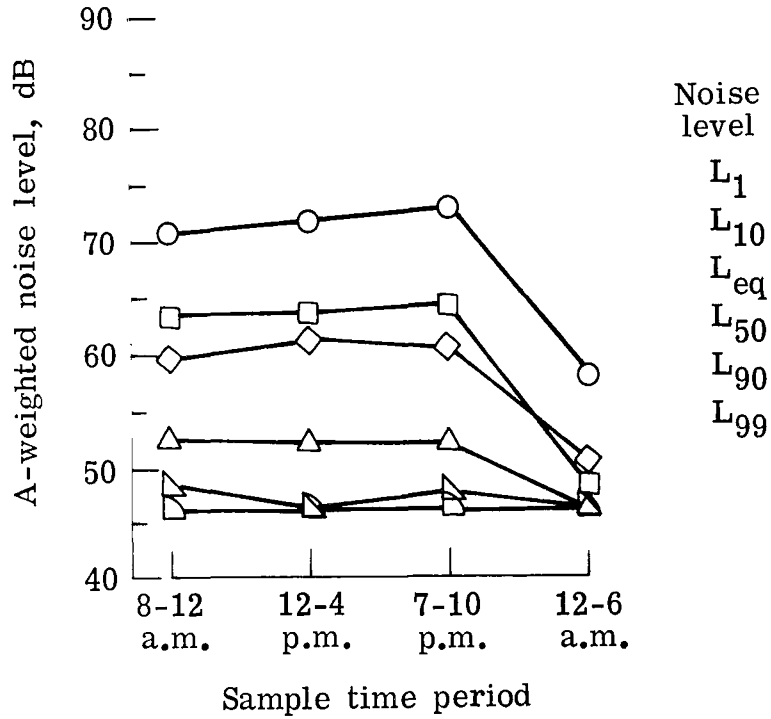


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A11.- Community site number 8 representative of a medium-aircraft-noise and low-street-noise impact area located at the intersection of Picadilly Downs and Trafalgar Square, Lynbrook and Valley Stream, New York.

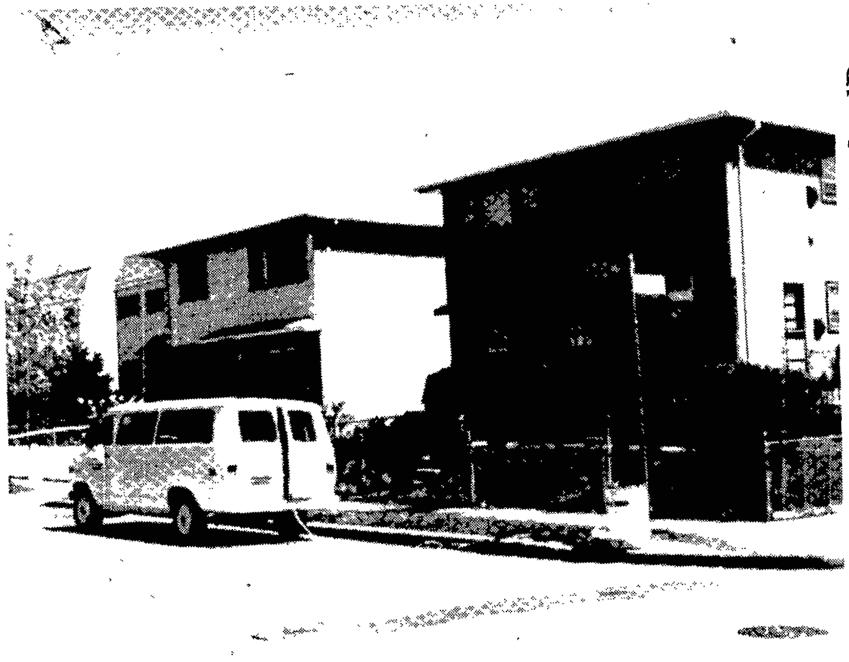
L-79-110

(a) Photograph of community site number 9.



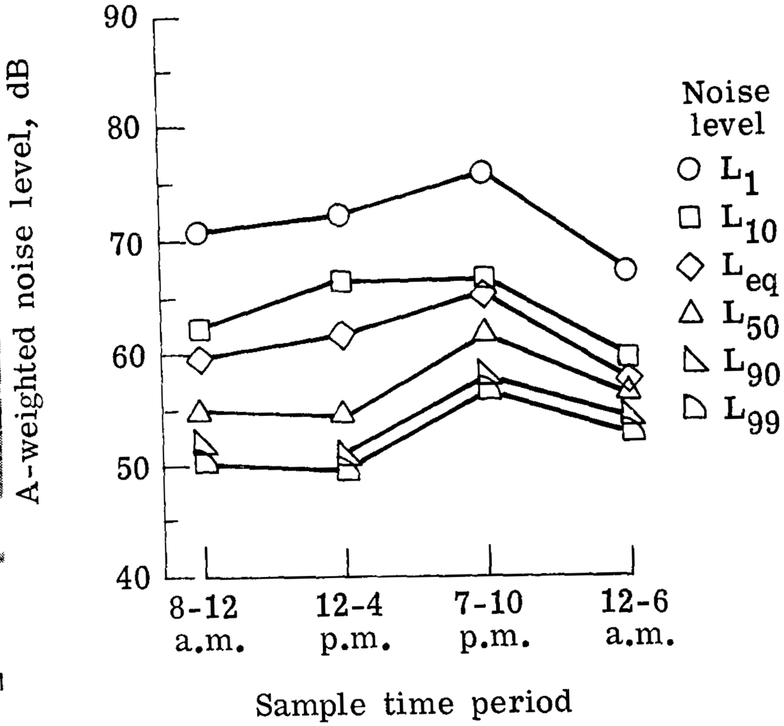
(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A12.- Community site number 9 representative of a medium-aircraft-noise and medium-street-noise impact area located at the intersection of Melrose and Cottage Streets, Valley Stream, New York.



L-79-111

(a) Photograph of community site number 10.

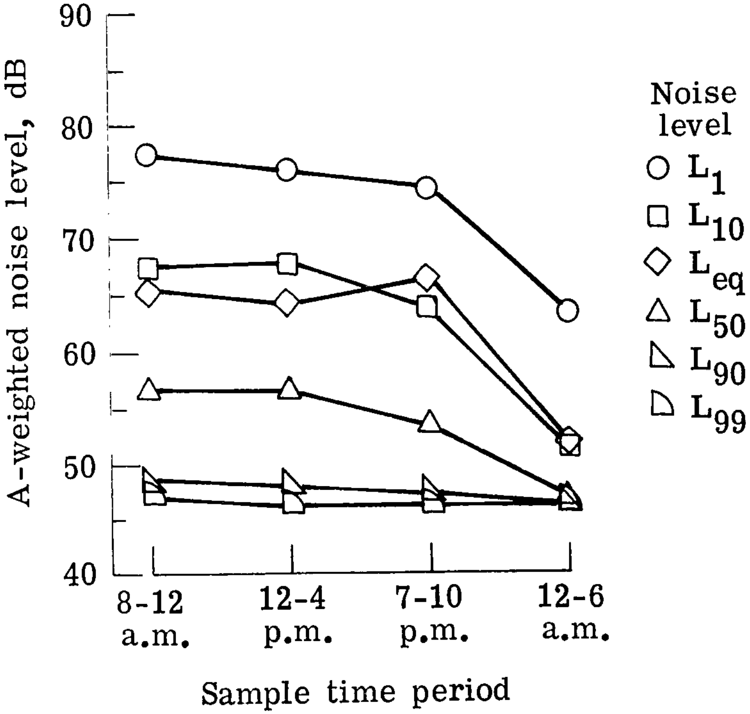


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A13.- Community site number 10 representative of a medium-aircraft-noise and medium-street-noise impact area located at the intersection of 144th and 167th Streets, Springfield Gardens, New York.

L-79-112

(a) Photograph of community site number 11.

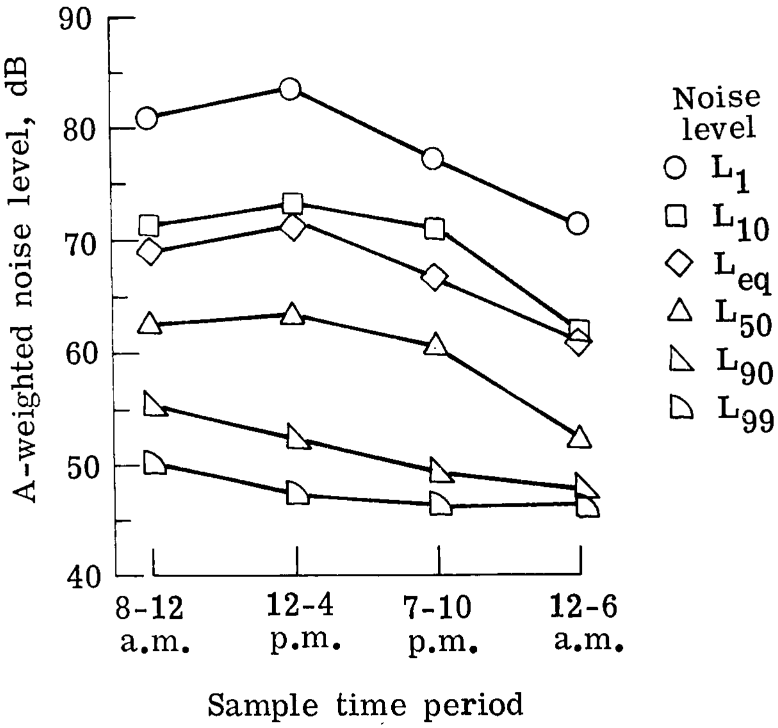


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A14.- Community site number 11 representative of a medium-aircraft-noise and high-street-noise impact area located at the intersection of Clearstream and Valley Stream, Valley Stream, New York.

L-79-113

(a) Photograph of community site number 12.

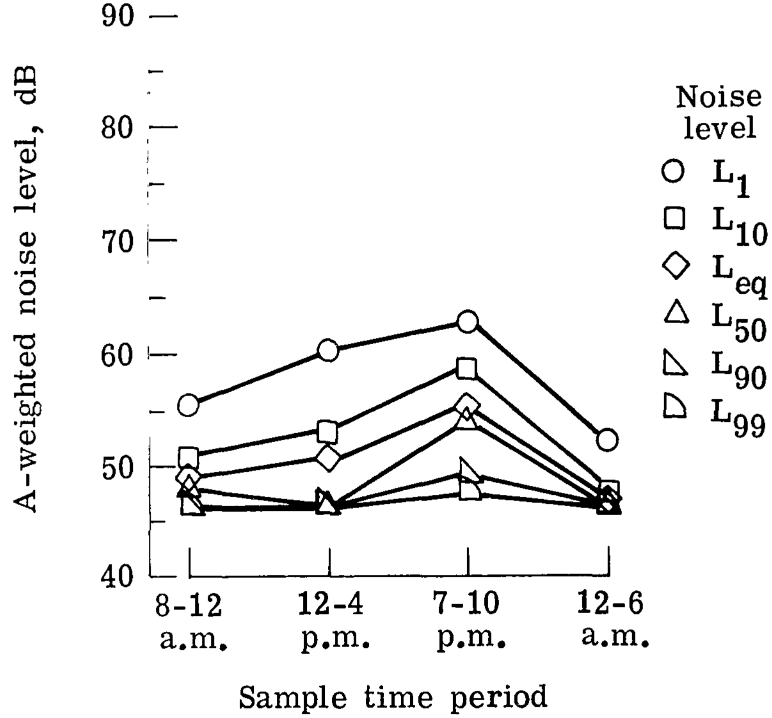


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A15.- Community site number 12 representative of a medium-aircraft-noise and high-street-noise impact area located at the intersection of Raymond and Atlantic Avenue, Lynbrook, New York.

L-79-114

(a) Photograph of community site number 13.

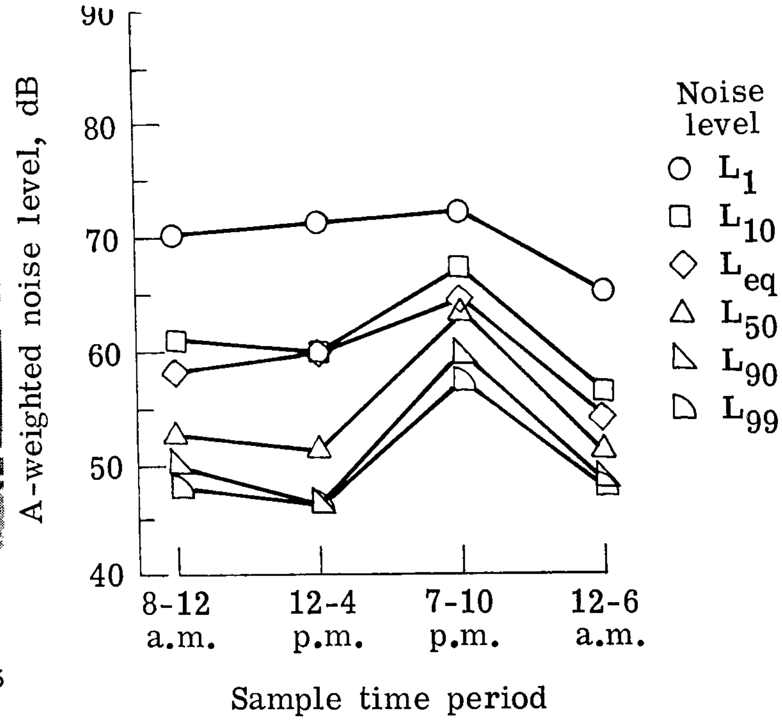


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A16.- Community site number 13 representative of a high-aircraft-noise and low-street-noise impact area located at the intersection of Whitehall and Cherry, South Valley Stream, New York.

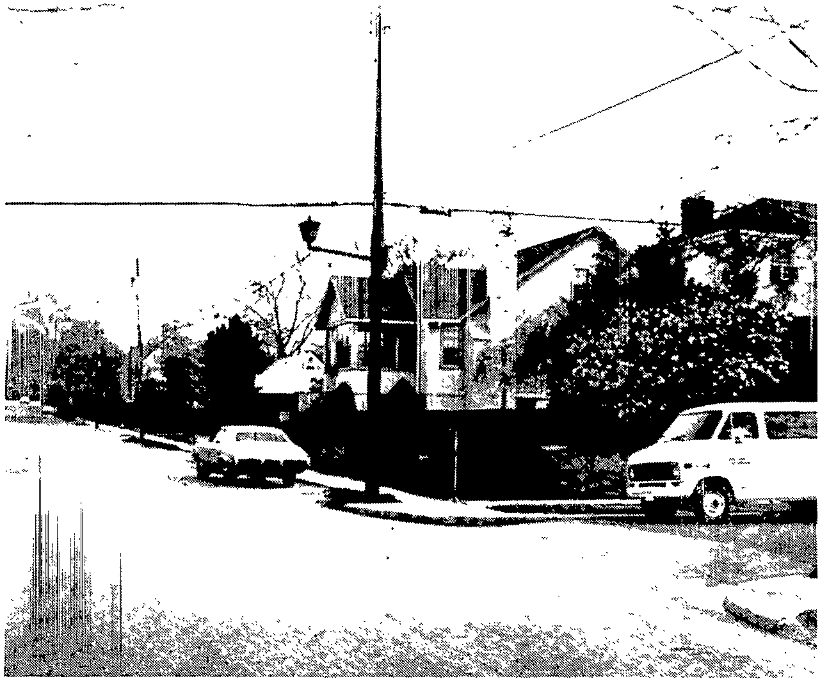
L-79-115

(a) Photograph of community site number 14.



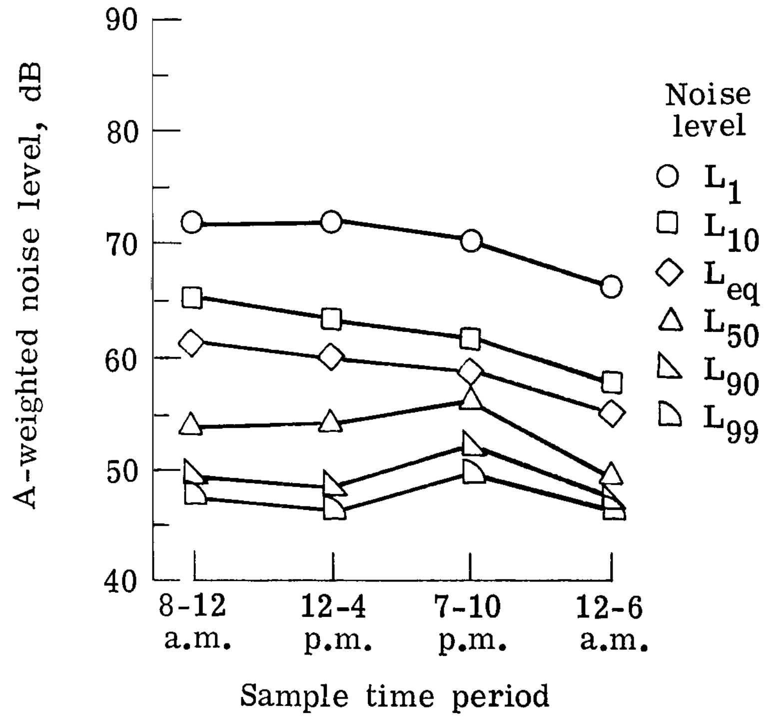
(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A17.- Community site number 14 representative of a high-aircraft-noise and low-street-noise impact area located at the intersection of 148th Drive and 241st Street, Rosedale, New York.



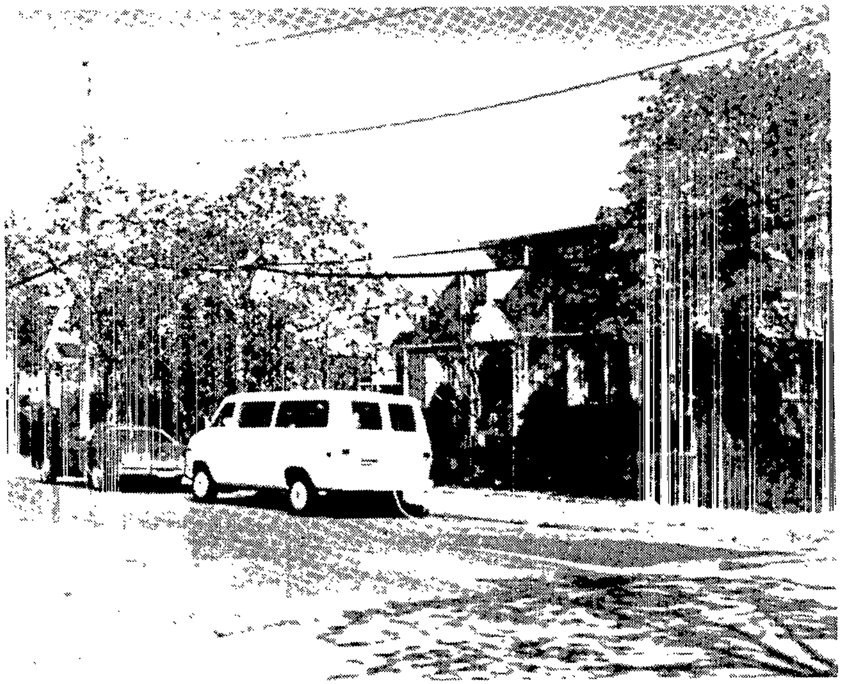
L-79-116

(a) Photograph of community site number 15.



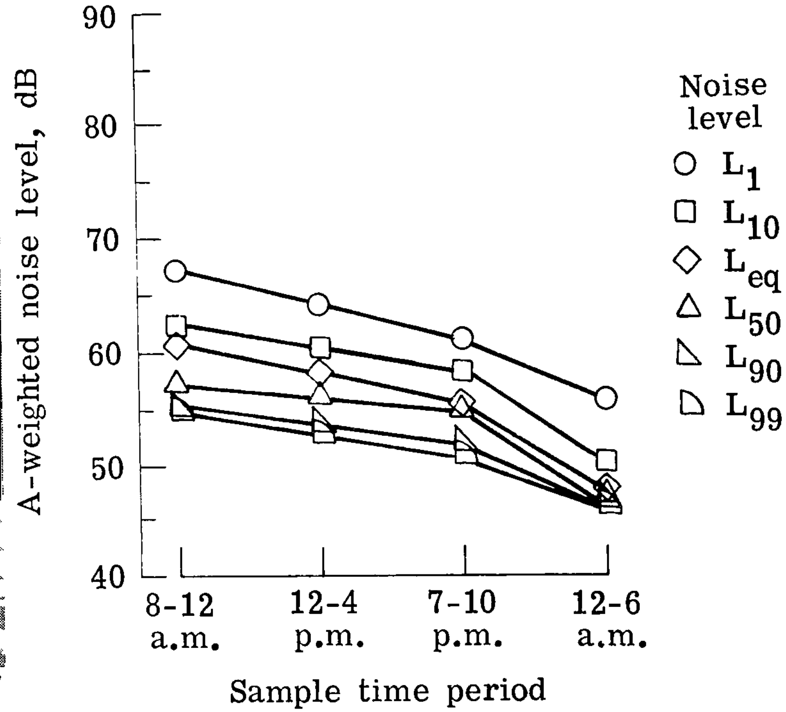
(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A18.- Community site number 15 representative of a high-aircraft-noise and medium-street-noise impact area located at the intersection of Argyle Road and Bayview, Cedarhurst, New York.



L-79-117

(a) Photograph of community site number 16.

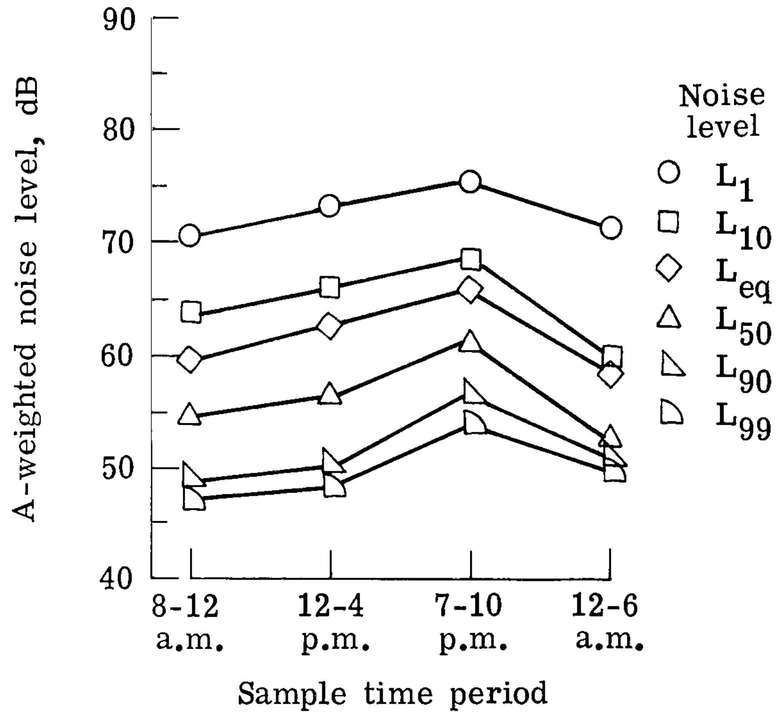


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A19.- Community site number 16 representative of a high-aircraft-noise and medium-street-noise impact area located at the intersection of Alden Avenue and Elizabeth, North Valley Stream, New York.

L-79-118

(a) Photograph of community site number 17.

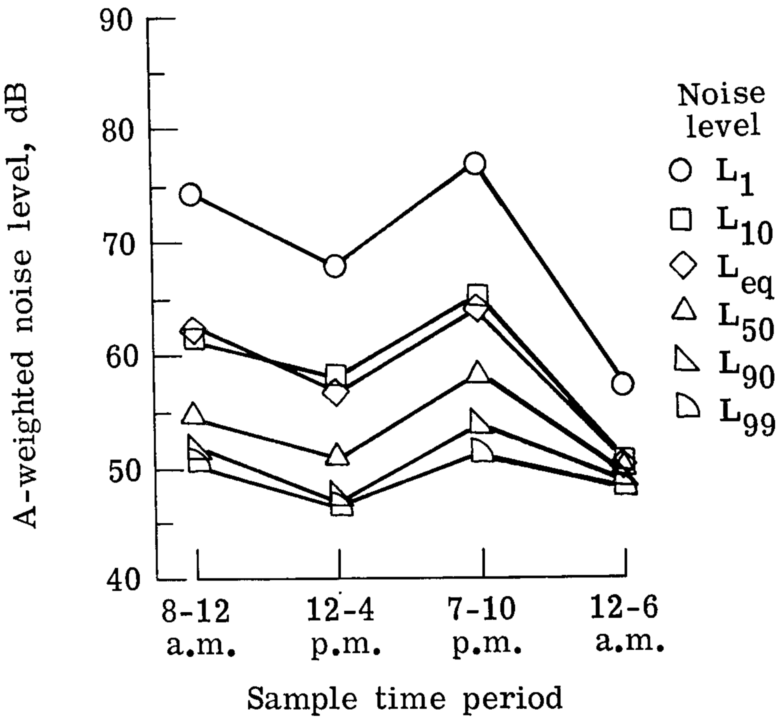


(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A20.- Community site number 17 representative of a high-aircraft-noise and high-street-noise impact area located at 159th Avenue and 89th Street, Howard Beach, New York.

L-79-119

(a) Photograph of community site number 18.



(b) Noise data of the measurement location. A-weighted noise level (where dB exceeded 1, 10, 50, 90, and 99 percent of the sample time, as well as an L_{eq} value for the same sample) as a function of sample time period.

Figure A21.- Community site number 18 representative of a high-aircraft-noise and high-street-noise impact area located at the intersection of 142nd Avenue and 241st Street, Rosedale, New York.

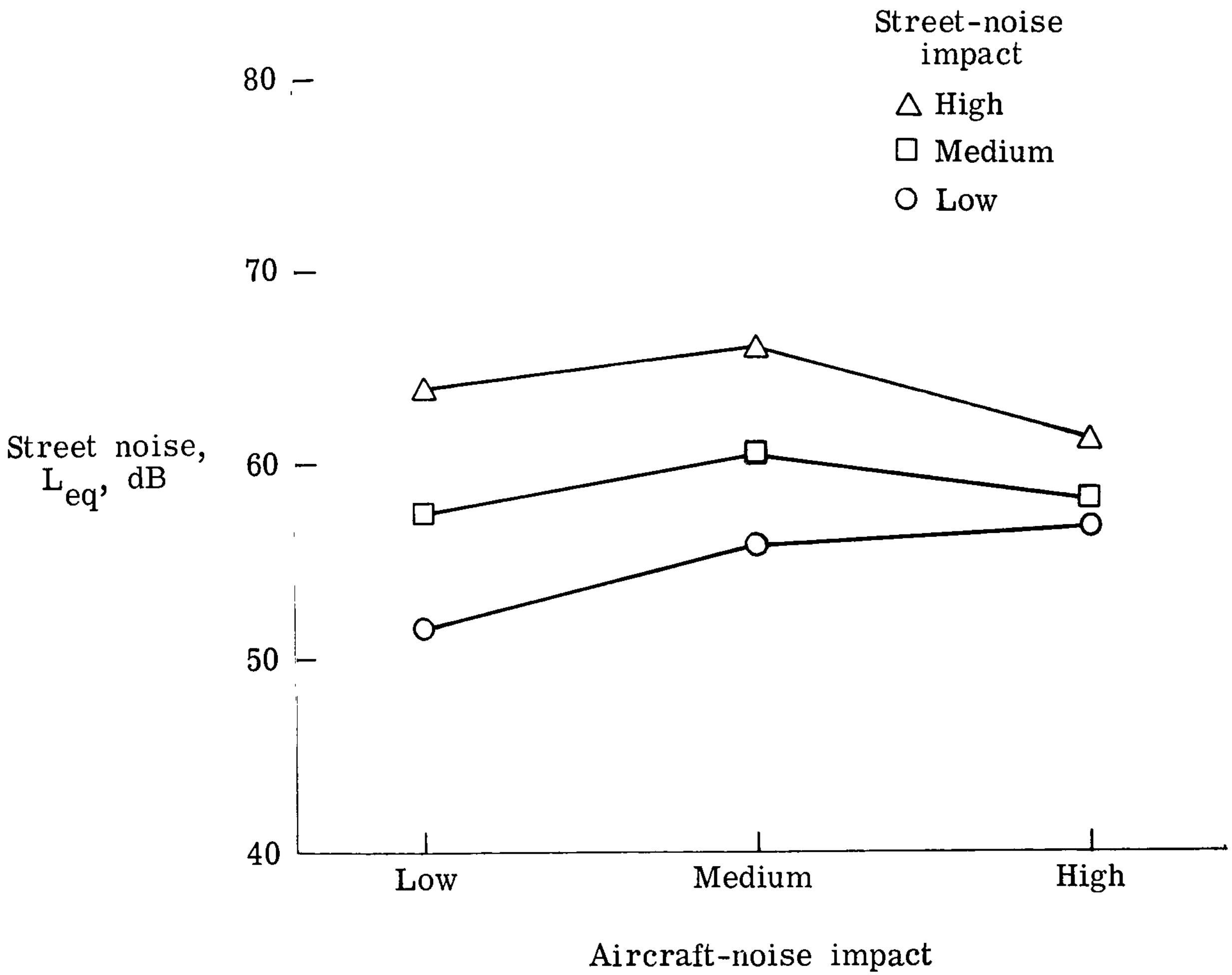


Figure A22.- Noise levels L_{eq} of three levels of street-noise impact (low, medium, and high) as a function of three levels of aircraft-noise impact (low, medium, and high).

APPENDIX B

CONSENT AND EVALUATION INSTRUCTIONS

Voluntary Consent Form for Subjects for Human Response to Aircraft Noise and Vibration

I understand the purpose of the research and the technique to be used, including my participation in the research, as explained to me by the Principal Investigator (or qualified designee).

I do voluntarily consent to participate as a subject in the human response to aircraft-noise experiment to be conducted at NASA Langley Research Center on ____.

Date

I understand that I may at any time withdraw from the experiment and that I am under no obligation to give reasons for withdrawal or to attend again for experimentation.

I undertake to obey the regulations of the laboratory and instructions of the Principal Investigator regarding safety, subject only to my right to withdraw declared above.

____

Signature of Subject

APPENDIX B

Voluntary Consent Form for Recording of Subjects' Response to Aircraft Noise and Vibration

I understand that AUDIO/VIDEO recordings are to be made of my response to the AIRCRAFT NOISE AND/OR VIBRATION experiment to be conducted at NASA Langley Research Center on ________________________, and that these recordings are to be held in strictest confidence.

I have been informed of the purpose of such recordings and do voluntarily consent to their use.

I further understand that I may withdraw my approval of such recordings at any time before or during the actual recording.

____

Signature of Subject

APPENDIX B

Instructions for Threshold Testing

The task you will now be required to perform is to evaluate the annoyance of several noises. I will specify the experimental number and beginning of a noise with the digital display located in the front of the room. Each noise will last for approximately 15 seconds. Then when the number display disappears, indicating that the noise has stopped, you are to evaluate the annoyance of the noise. The evaluation you provide is to be either that the noise was <u>annoying</u> (A), or that the noise was <u>not annoying</u> (NA).

Are there any questions?

Remember:

1. Watch the numerical display in front of the room for indication of the number of the noise.

2. Evaluate each noise as either annoying (A) or not annoying (NA).

3. Record your evaluation.

Are there any questions?

APPENDIX B

Instructions for Aircraft-Noise Evaluation

The task you will now be required to perform is to evaluate the degree of annoyance associated with various aircraft overflights. I will specify the flyover number and beginning of a noise with the digital display located in the front of the room. After the noise has stopped, you are to evaluate the annoyance of the aircraft noise. Evaluate the annoyance of each aircraft noise in terms of the following scale:

Zero annoyance								Maximum annoyance
0	1	2	3	4	5	6	7	8
|	|	|	|	|	|	|	|	|

There will be several seconds between successive aircraft flyovers to allow you to make your evaluation.

Evaluation marks.- You should record your evaluation of the annoyance associated with each aircraft noise by placing a checkmark (e.g., ✓) upon the scale. Try to be careful in recording your evaluations because the point of the checkmark (✓) will be used in interpretation of distance along the scale.

Scale interpretation.- The scale should be conceived of as representing the total range of annoyance you may associate with aircraft noise. In addition, the annoyance scale should be interpreted as if equal numerical distances represent equal amounts of annoyance. For example, the amount of annoyance between 1 and 2 is equal to the amount of annoyance between 5 and 6.

APPENDIX B

Consistency.- It is typical for participants in the study to "try to be consistent." Instead of trying to make evaluations consistent with previous aircraft flyover evaluations, try to evaluate each flyover without looking at previous evaluations. Please do not be concerned about whether your ratings agree with others in the room with you. Remember we want to know how different people feel about the aircraft flyovers. You may talk between the aircraft flyovers you are to rate, but please do not talk during them. It is also typical for participants to feel that they are not doing well at this task. It is usually true, however, that participants are doing better than they think they are, so don't be discouraged if you find the task difficult or monotonous at times.

Remember:

1. Watch the numerical display in front of the room for indication of the aircraft flyover number.

2. Evaluate the annoyance of each aircraft flyover.

3. Carefully record your evaluation mark.

Are there any questions?

APPENDIX C

DEMOGRAPHICS AND ATTITUDE SCALE

Demographics

1. Address: ______________________________

city ______ state ______ zip ______

2. Subject number ______________

3. Age ________ 4. Weight ________ 5. Sex ________

6. Education: Circle last grade completed.

Did not finish grade school 01
Did not finish high school 02
High School graduate 03
College through
    freshman 04
    sophomore 05
    (two year college graduate, A.A., A.S.) . . . 06
    junior 07
College graduate 08
Some post-graduate work 09
Master's Degree 10
Ph.D. or other doctorate degree 11
Professional degree (M.D., L.I.D. etc.) 12
Other (Specify) 13

____

7. Economic Level: Circle the category which best estimates the total combined income of your household last year before taxes. Please include income from <u>all</u> sources (i.e., wages, salaries, social security or retirement benefits, help from relatives, rent from property, etc.).

Under $5,000 01
$5,000 - $9,999 02
$10,000 - $14,999 03
$15,000 - $19,999 04
$20,000 - $24,999 05
$25,000 - $29,999 06
$30,000 or more 07

APPENDIX C

Subject No. ____________

Attitude Scale

DIRECTIONS: This form measures your attitudes on a number of important issues. Each item is a statement of belief or attitude. At the right of each statement is a place for you to indicate your feeling. Please circle the symbols that best express your point of view. Please respond in terms of how you feel, not how you think others feel or what society wants you to feel. The symbols at the right of each item are as follows:

SD - Strongly Disagree
D - Disagree
? - Undecided
A - Agree
SA - Strongly Agree

Circle the symbol that expresses your point of view.
WORK QUICKLY AND PLEASE RESPOND TO EVERY ITEM.

* * * * * *

1. I become upset more quickly when it's noisy.	SD	D	?	A	SA
2. Aircraft noise prevention really is not worth the effort required.	SD	D	?	A	SA
3. I believe that highway noise has gotten to be unbearable.	SD	D	?	A	SA
4. Airplanes sometimes bother me with their noise.	SD	D	?	A	SA
5. Airplane noise is not as big a problem as the noise made by the large trucks on the highway.	SD	D	?	A	SA
6. The increase in noise levels in our environment is one of our most serious problems.	SD	D	?	A	SA
7. I am very sensitive to air pollution.	SD	D	?	A	SA
8. Now and then, aircraft noise gets on my nerves.	SD	D	?	A	SA
9. Nothing is louder than a big airplane taking off.	SD	D	?	A	SA
10. One of the biggest factors in determining where I will buy or rent my next residence will be the noise level within the community.	SD	D	?	A	SA
11. The noise that airplanes make is a small price to pay for the convenience they provide.	SD	D	?	A	SA
12. Small changes in room temperature interfere with my concentration.	SD	D	?	A	SA

APPENDIX C

SD - Strongly Disagree
D - Disagree
? - Undecided
A - Agree
SA - Strongly Agree

* * *

13. Aircraft noise bothers only those few people who live near the large airports.	SD	D	?	A	SA
14. Aircraft noise is no more bothersome than any other type of noise.	SD	D	?	A	SA
15. Airports should be built in low population areas so that the noise of the planes annoy as few people as possible.	SD	D	?	A	SA
16. I can't work when there's any kind of noise.	SD	D	?	A	SA
17. Airplanes are one of the biggest sources of noise pollution.	SD	D	?	A	SA
18. I rarely even notice low flying aircraft.	SD	D	?	A	SA
19. Aircraft noise sometimes interferes with my T.V. watching.	SD	D	?	A	SA
20. There should be strict federal restrictions on noise levels of aircraft.	SD	D	?	A	SA
21. I cannot carry on an intelligent conversation if there is a lot of noise in the room.	SD	D	?	A	SA
22. Changes in temperature have a telling effect on me physically.	SD	D	?	A	SA
23. I am disturbed by the slightest change in a noise level I'm used to.	SD	D	?	A	SA
24. While aircraft noise causes me some irritability, I can quickly adapt to it.	SD	D	?	A	SA
25. Small changes in my normal environment are very disturbing to me.	SD	D	?	A	SA
26. A great many times sounds interfere with my train of thought.	SD	D	?	A	SA
27. While very loud aircraft noise is obnoxious, lower levels are easily tolerated.	SD	D	?	A	SA

APPENDIX C

SD - Strongly Disagree
D - Disagree
? - Undecided
A - Agree
SA - Strongly Agree

* * *

28. Noise that happens for a useful purpose bothers me less than needless noise.	SD D ? A SA
29. While low flying aircraft are certainly loud, they pass so quickly that the disturbance is minor.	SD D ? A SA
30. The convenience provided by modern aircraft outweighs the noise they contribute to the environment.	SD D ? A SA
31. While aircraft noise is at times irritating, the irritability it causes passes quickly.	SD D ? A SA
32. Large airports should be built in isolated areas where people are not likely to build houses.	SD D ? A SA
33. There is too much fuss being made over airplane noise.	SD D ? A SA
34. When I'm eating, odors from the kitchen are often annoying.	SD D ? A SA
35. Many other types of noise are more annoying than aircraft noise.	SD D ? A SA
36. Persons living near big airports are probably not bothered by the noise after awhile.	SD D ? A SA
37. I am to some degree temperamental about small changes in my environment.	SD D ? A SA
38. I am annoyed by excessive aircraft noise only occasionally.	SD D ? A SA
39. If I lived near an airport, I would stay indoors as much as possible.	SD D ? A SA
40. When I travel from a warm climate to a cold one, I have a lot of trouble adjusting.	SD D ? A SA
41. Only extremely loud noise from airplanes bother me at all.	SD D ? A SA
42. Some of the time aircraft noise makes it very unpleasant to be outdoors.	SD D ? A SA

APPENDIX C

SD - Strongly Disagree
D - Disagree
? - Undecided
A - Agree
SA - Strongly Agree

* * *

43. Like just about anything, you can get used to aircraft noise if you have to.	SD	D	?	A	SA
44. I find that I only notice aircraft noise when it is much louder than normal.	SD	D	?	A	SA
45. Even the smallest increase in a noise level, say of a lawnmower, is very annoying to me.	SD	D	?	A	SA
46. Aircraft noise only really disturbs me when I'm thinking about a difficult problem.	SD	D	?	A	SA
47. When I'm working, I need a controlled environment with no interruption.	SD	D	?	A	SA
48. It doesn't take much noise above what I'm used to to disrupt my thinking.	SD	D	?	A	SA
49. I am slightly irritated by aircraft noise.	SD	D	?	A	SA
50. It is doubtful whether excessive aircraft noise is so bad.	SD	D	?	A	SA
51. Aircraft noise bothers me so infrequently that I don't even consider it a problem.	SD	D	?	A	SA
52. I can tolerate aircraft noise though it is moderately irritating.	SD	D	?	A	SA
53. Aircraft noise has very little effect on me in any way.	SD	D	?	A	SA
54. The best environment for me is one in which there is total quiet.	SD	D	?	A	SA
55. Although airplane noise is irritating, it probably is not doing any harm.	SD	D	?	A	SA
56. When I am reading, I prefer only a certain amount of illumination.	SD	D	?	A	SA
57. I am seldom bothered by the sounds of low flying aircraft.	SD	D	?	A	SA

APPENDIX C

SD - Strongly Disagree
D - Disagree
? - Undecided
A - Agree
SA - Strongly Agree

* * *

58. The constant level of aircraft noise is probably damaging the health of people living near airports.	SD	D	?	A	SA
59. I am more sensitive to harsh noises than most people.	SD	D	?	A	SA
60. At work, a change in my environment can really upset my concentration.	SD	D	?	A	SA

REFERENCES

1. Edge, Philip M., Jr.; and Cawthorn, Jimmy M.: Selected Methods for Quantification of Community Exposure to Aircraft Noise. NASA TN D-7977, 1976.

2. Conner, William K.; and Patterson, Harrold P.: Community Reaction to Aircraft Noise Around Smaller City Airports. NASA CR-2104, 1972.

3. Corso, John F.: A Theoretico-Historical Review of the Threshold Concept. Psychol. Bull., vol. 60, no. 4, July 1963, pp. 356-370.

4. Kryter, Karl D.: The Effects of Noise on Man. Academic Press, Inc., 1970.

5. Pearsons, Karl S.; and Bennett, Ricarda L.: Handbook of Noise Ratings. NASA CR-2376, 1974.

6. Borsky, Paul N.: A Comparison of a Laboratory and Field Study of Annoyance and Acceptability of Aircraft Noise Exposures. NASA CR-2772, 1977.

7. Borsky, Paul N.: A New Field-Laboratory Methodology for Assessing Human Response to Noise. NASA CR-2221, 1973.

8. Community Reaction to Airport Noise - Volume I. NASA CR-1761, 1971.

9. American National Standard Specifications for Audiometers. S3.6-1969, American Natl. Stand. Inst., Inc., June 19, 1969.

10. Hearing Levels of Adults. Public Health Serv. Publ. No. 1000, Ser. 11, No. 31, U.S. Dep. Health, Educ., & Welfare, May 1968.

11. American National Standard Specification for Sound Level Meters. S1.4-1971, American Natl. Stand. Inst., Inc., Apr. 27, 1961.

12. Powell, Clemans A.: Judgments of Relative Noisiness of a Supersonic Transport and Several Commercial-Service Aircraft. NASA TN D-8434, 1977.

13. Anastasi, Anne: Psychological Testing. Third ed., Macmillan Co., c.1968.

14. Winer, B. J.: Statistical Principles in Experimental Design. Second ed., McGraw-Hill Book Co., Inc., c.1971.

15. Symposium on Noise in Transportation. Inst. Sound & Vib. Res., Univ. Southhampton, July 1974.

16. Wyle Laboratories: Community Noise. NTID300.3, U.S. Environ. Prot. Agency, Dec. 31, 1971.

TABLE I.- SUBJECT DEMOGRAPHICS

Subjects			Subject group (laboratory)		
			VA_{LRC}	NY_{LRC}	NY_{CU}
Number		Males Females Total	17 63 80	26 3 29	63 81 144
Age		Median Range	30 18 to 56	49 37 to 69	33.0 18 to 79
Audiogram[a]	Pre	Mean St. dev.[b]	5.24 2.83	20.04 12.43	11.26 11.76
	Post	Mean St. dev.[b]	4.98 2.74	20.07 12.03	9.99 10.37
	Total	Mean St. dev.[b]	5.11 2.78	20.05 12.12	10.62 10.56

[a]The decibel-level increases required to achieve hearing threshold.
[b]Standard deviation.

TABLE II.- TEST SCHEDULE

Activity	Time duration
Audiogram	Prior to testing
Prethreshold testing	15 minutes
Aircraft overflights	30 minutes
Break	10 minutes
Aircraft overflights	30 minutes
Attitude tests	75 minutes
Break	15 minutes
Aircraft modifications	30 minutes
Attitude tests	25 minutes
Postthreshold testing	15 minutes
Audiogram	After testing

TABLE III.- SUMMARY OF ANALYSES OF VARIANCE OF ANNOYANCE RESPONSES TO AIRCRAFT OVERFLIGHTS FOR SUBJECTS FROM VIRGINIA (VA_{LRC})

Source	Sum of squares	Degrees of freedom	Mean square	F ratio	Explained variance, percent
P airplane type	101.7444	6	16.95739	[a]13.4287	0.29
Error (S × P)	598.5553	474	1.262775	---------	1.86
O operation	209.8059	1	209.8059	[a]100.5484	0.65
Error (S × O)	164.8426	79	2.086615	---------	.51
N noise level	19044.31	3	6348.104	[a]914.4005	59.18
Error (S × N)	1645.341	237	6.942367	---------	5.12
S subjects	5218.661	79	66.05900	---------	16.24
P × O interaction	645.4521	6	107.5754	[a]85.5362	1.98
Error (S × P × O)	596.1303	474	1.257659	---------	1.86
P × N interaction	98.67969	18	5.482205	[a]4.7312	0.24
Error (S × P × N)	1647.732	1422	1.158743	---------	5.13
O × N interaction	75.87036	3	25.29012	[a]16.5030	0.22
Error (S × O × N)	363.1916	237	1.532454	---------	1.13
P × O × N interaction . .	139.8010	18	7.766724	[a]6.5853	0.37
Error (S × P × O × N) . .	1677.099	1422	1.179394	---------	5.22

[a]Probability is less than 0.05.

TABLE IV.- SUMMARY OF ANALYSES OF VARIANCE OF ANNOYANCE RESPONSES TO AIRCRAFT OVERFLIGHTS FOR SUBJECTS FROM NEW YORK (NY_{LRC})

Source	Sum of squares	Degrees of freedom	Mean square	F ratio	Explained variance, percent
P airplane type	124.6804	6	20.78006	[a]15.5857	0.98
Error (S × P)	223.9903	168	1.333276	---------	1.88
O operation	31.86958	1	31.86958	[a]13.2618	0.25
Error (S × O)	67.28733	28	2.403119	---------	.57
N noise level	7659.405	3	2553.134	[a]466.2501	64.26
Error (S × N)	459.9749	84	5.475891	---------	3.87
S subjects	1513.780	28	54.06358	---------	12.73
P × O interaction	235.9905	6	39.33175	[a]27.5513	1.91
Error (S × P × O)	239.8337	168	1.427581	---------	2.02
P × N interaction	63.83411	18	3.546339	[a]3.2964	0.37
Error (S × P × N)	542.2060	504	1.075806	---------	4.56
O × N interaction	7.524414	3	2.508138	2.0929	0.33
Error (S × O × N)	100.6635	84	1.198375	---------	.85
P × O × N interaction . .	135.9023	18	7.550123	[a]7.2025	0.98
Error (S × P × O × N) . .	528.3218	504	1.048257	---------	4.44

[a]Probability is less than 0.05.

TABLE V.- SUMMARY OF ANALYSES OF VARIANCE OF ANNOYANCE RESPONSES TO AIRCRAFT OVERFLIGHTS FOR SUBJECTS FROM NEW YORK TESTED AT COLUMBIA UNIVERSITY (NY_{CU})

Source	Sum of squares	Degrees of freedom	Mean square	F ratio	Explained variance, percent
A aircraft noise impact . . .	30.65	2	15.32	0.20	0.00
Error S × (A × B)	10287.68	135	76.21	--------	18.15
B street noise	68.37	2	34.18	0.45	0.00
Error S × (A × B)	10287.68	135	76.21	--------	18.15
P airplane type	297.06	6	49.51	[a]30.25	0.51
Error S × P × (A × B)	1325.90	810	1.64	--------	2.34
O operation	251.74	1	251.74	[a]95.29	0.44
Error S × O × (A × B)	356.67	135	2.64	--------	.63
N noise level	31707.23	3	10569.08	[a]1486.88	55.91
Error S × N × (A × B)	2878.84	405	7.11	--------	5.08
A × B interaction	128.81	4	32.20	0.42	0.00
Error S × (A × B)	10287.68	135	76.21	--------	18.15
A × P interaction	18.72	12	1.56	0.95	0.00
Error S × P × (A × B)	1325.90	810	1.64	--------	2.34
S × P interaction	22.44	12	1.87	1.14	0.05
Error S × P × (A × B)	1325.90	810	1.64	--------	2.34
A × O interaction	13.39	2	6.70	2.53	0.01
Error S × O × (A × B)	356.67	135	2.64	--------	.63
B × O interaction	0.81	2	0.40	0.15	0.00
Error S × O × (A × B)	356.67	135	2.64	--------	.63
P × O interaction	941.85	6	156.98	[a]100.23	1.64
Error S × P × O × (A × B) . .	1268.61	810	1.57	--------	2.24
A × N interaction	22.41	6	3.47	0.53	0.00
Error S × N × (A × B)	2878.84	405	7.11	--------	5.08
B × N interaction	38.70	6	6.45	0.91	0.00
Error S × N × (A × B)	2878.84	405	7.11	--------	5.08
P × N interaction	128.47	18	7.18	[a]5.91	0.19
Error S × P × N × (A × B) . .	2936.33	2430	1.21	--------	5.18
O × N interaction	87.25	3	29.08	[a]17.64	0.15
Error S × O × N × (A × B) . .	667.64	405	1.65	--------	1.18

[a]Probability is less than 0.05.

TABLE V.- Concluded

Source	Sum of squares	Degrees of freedom	Mean square	F ratio	Explained variance, percent
A × B × P interaction	63.24	24	2.63	[a]1.61	0.06
Error S × P × (A × B)	1325.90	810	1.64	-----	2.34
A × B × O interaction	14.56	4	3.64	1.38	0.01
Error S × O × (A × B)	356.67	135	2.64	-----	.63
A × P × O interaction	41.94	12	3.50	[a]2.23	0.04
Error S × P × O × (A × B)	1268.61	810	1.57	-----	2.24
B × P × O interaction	18.68	12	1.56	0.99	0.00
Error S × P × O × (A × B)	1268.61	810	1.57	-----	2.24
A × B × N interaction	92.74	12	7.73	1.09	0.01
Error S × N × (A × B)	2878.84	405	7.11	-----	5.08
A × P × N interaction	55.87	36	1.55	1.28	0.02
Error S × P × N × (A × B)	2936.33	2430	1.21	-----	5.18
B × P × N interaction	59.35	36	1.65	1.36	0.03
Error S × P × N × (A × B)	2936.33	2430	1.21	-----	5.18
A × O × N interaction	8.24	6	1.37	0.83	0.00
Error S × O × N × (A × B)	667.64	405	1.65	-----	1.18
B × O × N interaction	9.73	6	1.62	0.98	0.00
Error S × O × N × (A × B)	667.64	405	1.65	-----	1.18
P × O × N interaction	139.05	18	7.73	[a]5.73	0.20
Error S × P × O × N × (A × B) . .	3276.30	2430	1.35	-----	5.78
A × B × P × O interaction	28.96	24	1.21	0.77	0.00
Error S × P × O × (A × B)	1268.61	810	1.57	-----	2.24
A × B × P × N interaction	91.95	72	1.28	1.05	0.01
Error S × P × N × (A × B)	2936.33	2430	1.21	-----	5.18
A × B × O × N interaction	22.31	12	1.86	1.13	0.00
Error S × O × N × (A × B)	667.64	405	1.65	-----	1.18
A × P × O × N interaction	77.63	36	2.16	[a]1.60	0.05
Error S × P × O × N × (A × B) . .	3276.30	2430	1.35	-----	5.78
B × P × O × N interaction	63.07	36	1.75	1.30	0.03
Error S × P × O × N × (A × B) . .	3276.30	2430	1.35	-----	5.78
A × B × P × O × N interaction . .	125.76	72	1.75	1.30	0.05
Error S × P × O × N × (A × B) . .	3276.30	2430	1.35	-----	5.78

[a]Probability is less than 0.05.

TABLE VI.- SUMMARY OF STEPWISE MULTIPLE-CORRELATION ANALYSIS FOR SUBJECTS TESTED AT LANGLEY RESEARCH CENTER (VA_{LRC} AND NY_{LRC}) IN WHICH THE PREDICTORS OF AN INDIVIDUAL'S AIRCRAFT ADAPTATION LEVEL INCLUDED THE VARIOUS ATTITUDE-PERSONALITY INDICES

Step number	Variable removed (pyschological index)	Subjective scale	Multiple correlation	Explained variance	Simple correlation
1	Noise attitudes	See appendix B	0.3884	0.1509	-0.388
2	Education level	Demographics	.4842	.2345	-.336
3	Income level	Demographics	.5226	.2731	-.315
4	Counseling readiness	Adjective checklist	.5503	.3029	-.169
5	Weight	Demographics	.5754	.3311	-.216
6	Environmental sensitivity	See appendix B	.5892	.3472	-.093
7	Exhibition	Adjective checklist	.5976	.3571	.101
8	Postaudiogram	Audiogram	.6070	.3684	-.267
9	Aggression	Adjective checklist	.6161	.3795	-.102
10	Intraception	Adjective checklist	.6344	.4024	-.147
11	Embedded figure scale no. 2	Group embedded figure	.6472	.4188	-.060
12	Embedded figure scale no. 1	Group embedded figure	.6638	.4406	-.194
13	Aircraft attitudes	See appendix B	.6727	.4526	.282
14	Autonomy	Adjective checklist	.6785	.4603	-.051
15	Judgment-perception	Myers-Briggs type indicator	.6857	.4702	.099
16	Trait anxiety	State-trait anxiety inventory	.6911	.4776	.016
17	Preaudiogram	Audiogram	.6943	.4821	-.242
18	State anxiety	State-trait anxiety inventory	.6977	.4868	-.168
19	Change	Adjective checklist	.7015	.4922	-.232
20	Total adjectives marked	Adjective checklist	.7034	.4948	-.045
21	Self control	Adjective checklist	.7057	.4981	.054
22	Order	Adjective checklist	.7077	.5008	-.141
23	Endurance	Adjective checklist	.7114	.5061	-.057
24	Self confidence	Adjective checklist	.7176	.5149	-.116
25	Achievement	Adjective checklist	.7196	.5178	-.002
26	Nurturance	Adjective checklist	.7214	.5204	.060
27	Personal adjustment	Adjective checklist	.7238	.5239	.031
28	Favorable adjectives	Adjective checklist	.7249	.5255	.101
29	Extraversion-introversion	Myers-Briggs type inventory	.7266	.5280	.002
30	Lability	Adjective checklist	.7279	.5298	-.063
31	Heterosexuality	Adjective checklist	.7288	.5311	.077
32	Abasement	Adjective checklist	.7301	.5331	-.045
33	Thinking-feeling	Myers-Briggs type inventory	.7308	.5340	-.035
34	Sex	Demographics	.7311	.5345	.296
35	Age	Demographics	.7313	.5348	-.247
36	Succorance	Adjective checklist	.7314	.5350	-.031
37	Affiliation	Adjective checklist	.7315	.5351	.135
38	Sensing-intuition	Myers-Briggs type inventory	.7316	.5352	-.110
39	Unfavorable adjectives	Adjective checklist	.7317	.5353	.060
40	Dominance	Adjective checklist	------	------	------
41	Deference	Adjective checklist	------	------	------
42	Mean audiogram	Audiogram	------	------	------

TABLE VII.- SUMMARY OF STEPWISE MULTIPLE-CORRELATION ANALYSIS FOR SUBJECTS TESTED AT COLUMBIA UNIVERSITY (NY_{CU}) IN WHICH THE PREDICTORS OF AN INDIVIDUAL'S AIRCRAFT ADAPTATION LEVEL INCLUDED THE VARIOUS ATTITUDE-PERSONALITY INDICES AND NOISE-IMPACT MEASURES

Step number	Variable removed (pyschological index)	Subjective scale	Multiple correlation	Explained variance	Simple correlation
1	Noise attitudes	See appendix B	0.3241	0.1050	0.3240
2	Change	Adjective checklist	.3666	.1344	.1820
3	Sex	Demographics	.3874	.1501	.1100
4	Judgment-perception	Myers-Briggs type indicator	.4066	.1654	.0100
5	Deference	Adjective checklist	.4220	.1781	-.0080
6	Noise exposure forecast, NEF	Aircraft-noise impact measure	.4337	.1881	-.1610
7	State of anxiety	State-trait anxiety inventory	.4419	.1953	-.0980
8	Agression	Adjective checklist	.4493	.2018	.0270
9	Self control	Adjective checklist	.4586	.2103	.0130
10	Order	Adjective checklist	.4608	.2190	-.0730
11	Endurance	Adjective checklist	.4795	.2299	-.0180
12	Equivalent sound level, L_{eq}	Street-noise impact measure	.4883	.2384	-.1090
13	Heterosexuality	Adjective checklist	.4950	.2450	-.0060
14	Favorable adjective	Adjective checklist	.5072	.2572	.0780
15	Environmental attitudes	See appendix B	.5120	.2621	.2220
16	Exhibition	Adjective checklist	.5159	.2662	.0250
17	Income	Demographics	.5212	.2717	.1080
18	Extraversion-introversion	Myers-Briggs type indicator	.5257	.2763	.0680
19	Unfavorable adjectives	Adjective checklist	.5301	.2810	-.0110
20	Succorance	Adjective checklist	.5399	.2915	-.0460
21	Counseling readiness	Adjective checklist	.5437	.2956	-.1330
22	Defensiveness	Adjective checklist	.5476	.2998	.0380
23	Nurturance	Adjective checklist	.5524	.3051	.0040
24	Thinking-feeling	Myers-Briggs type indicator	.5559	.3090	.0050
25	Aircraft attitudes	See appendix B	.5592	.3127	-.1060
26	Self confidence	Adjective checklist	.5615	.3152	.0250
27	Achievement	Adjective checklist	.5687	.3234	.0740
28	Lability	Adjective checklist	.5718	.3270	.0440
29	Abasement	Adjective checklist	.5739	.3294	.0110
30	Total adjectives marked	Adjective checklist	.5772	.3331	-.0650
31	Dominance	Adjective checklist	.5784	.3345	.0510
32	Embedded figure scale no. 2	Group embedded figure	.5797	.3360	.0670
33	Age	Demographics	.5821	.3388	-.0820
34	Postaudiogram	Audiogram	.5838	.3408	-.0290
35	Trait anxiety	State-trait anxiety inventory	.5853	.3425	-.0360
36	Education	Demographics	.5869	.3445	.0520
37	Sensing-intuition	Myers-Briggs type indicator	.5873	.3449	-.1010
38	Preaudiogram	Audiogram	.5877	.3454	-.0290
39	Autonomy	Adjective checklist	.5880	.3457	.0050
40	Personal adjustment	Adjective checklist	.5881	.3459	.0230

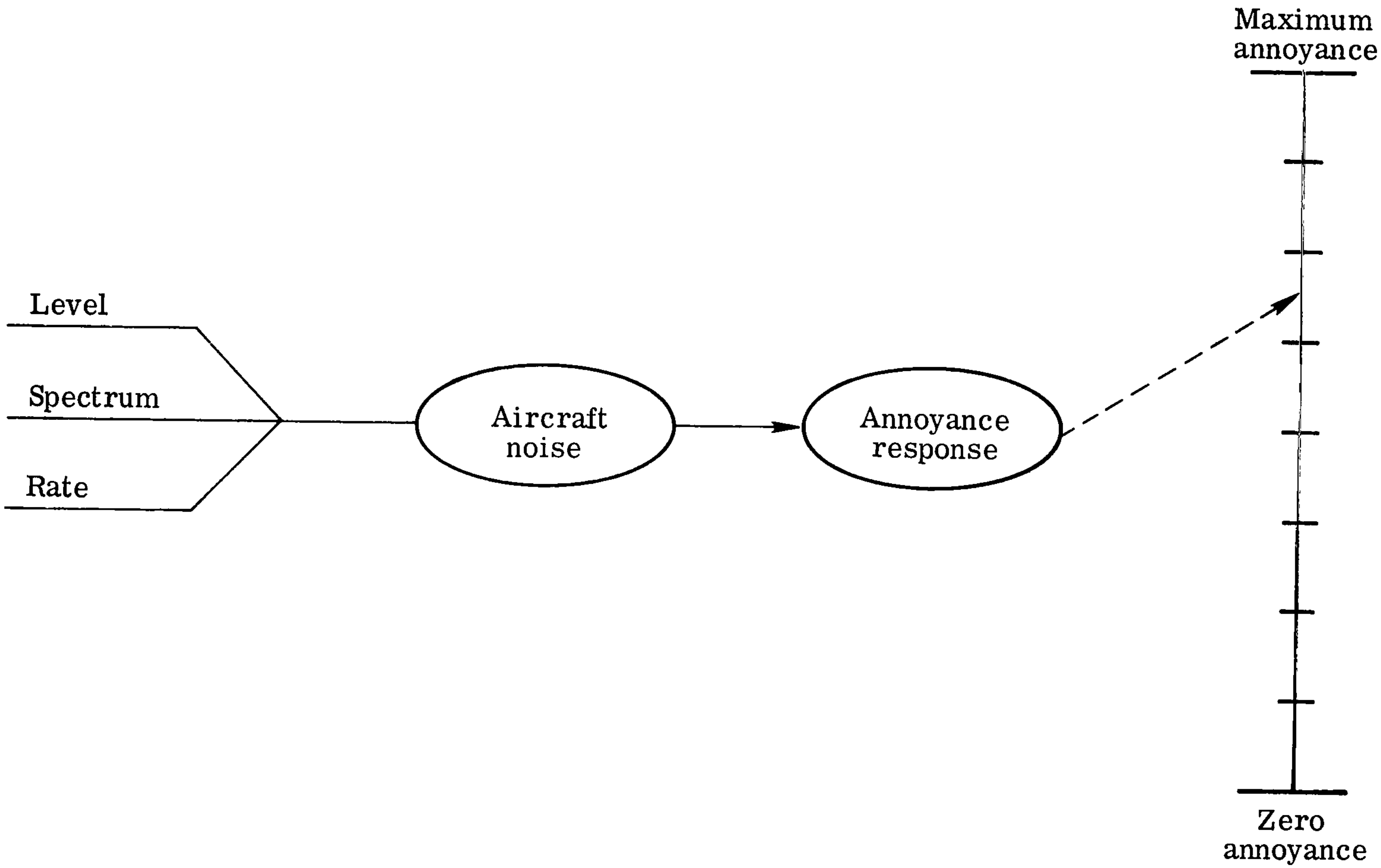


Figure 1.- Traditional aircraft-noise study technique.

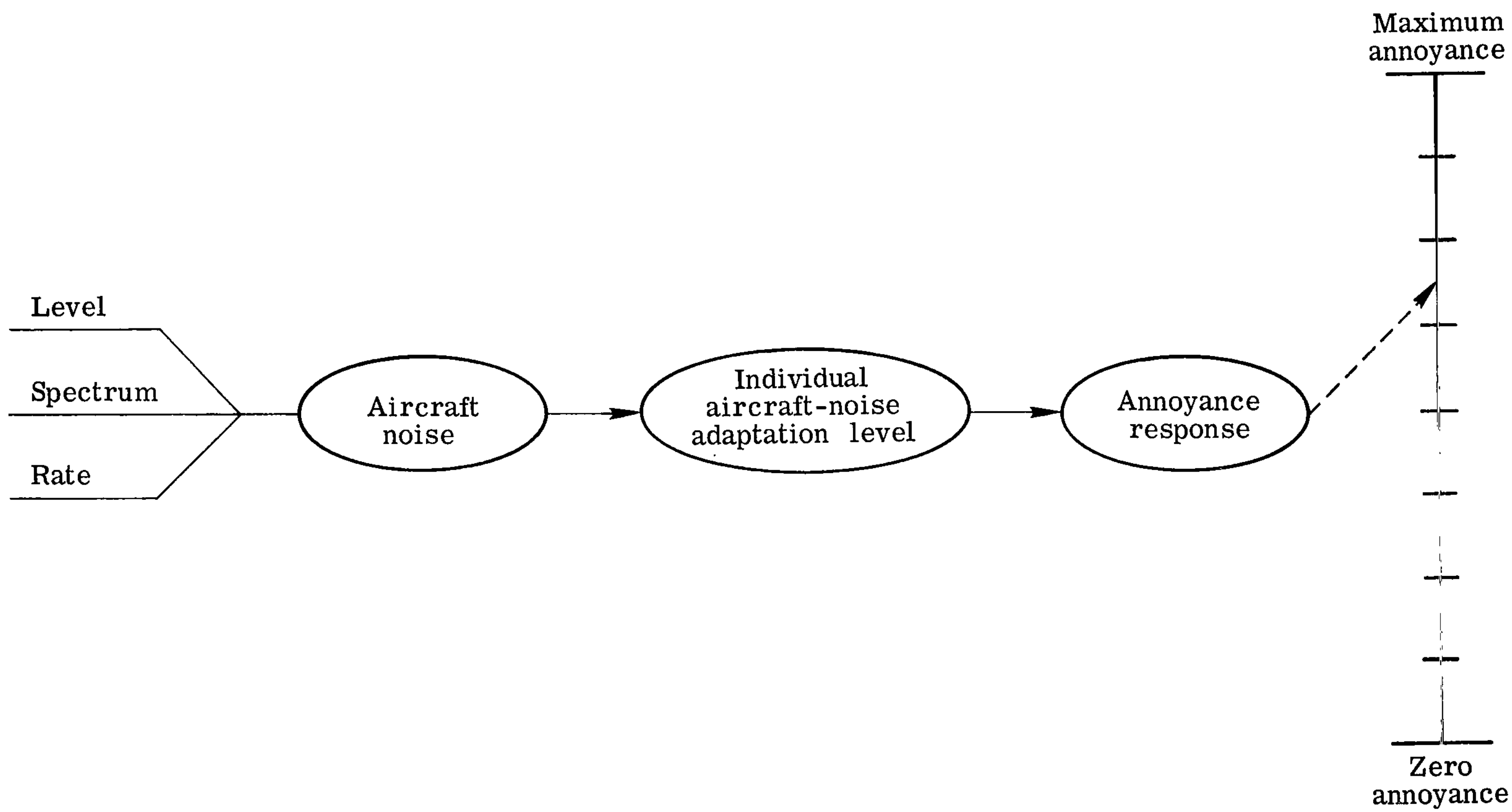


Figure 2.- Aircraft-noise study technique incorporating aircraft adaptation model.

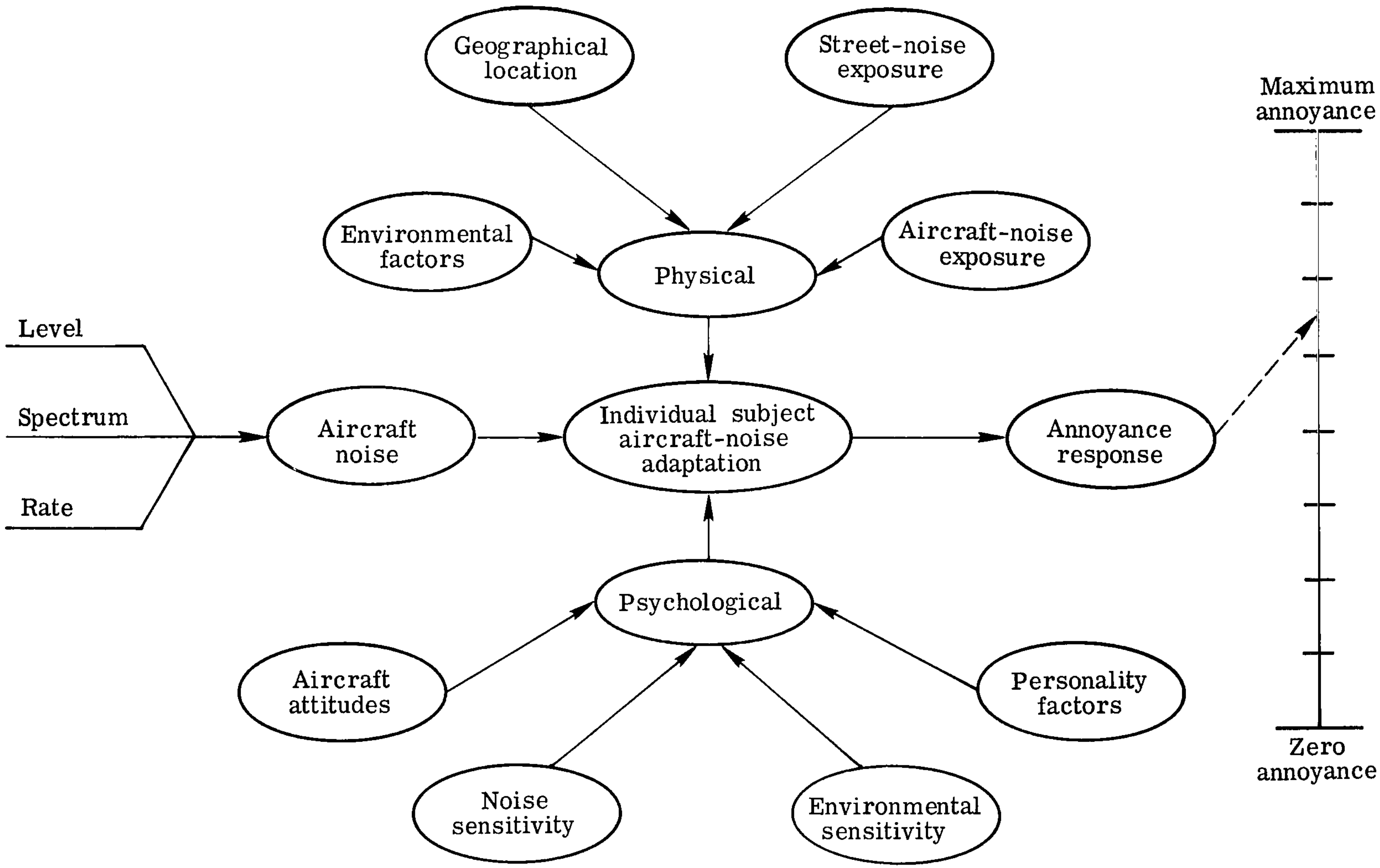
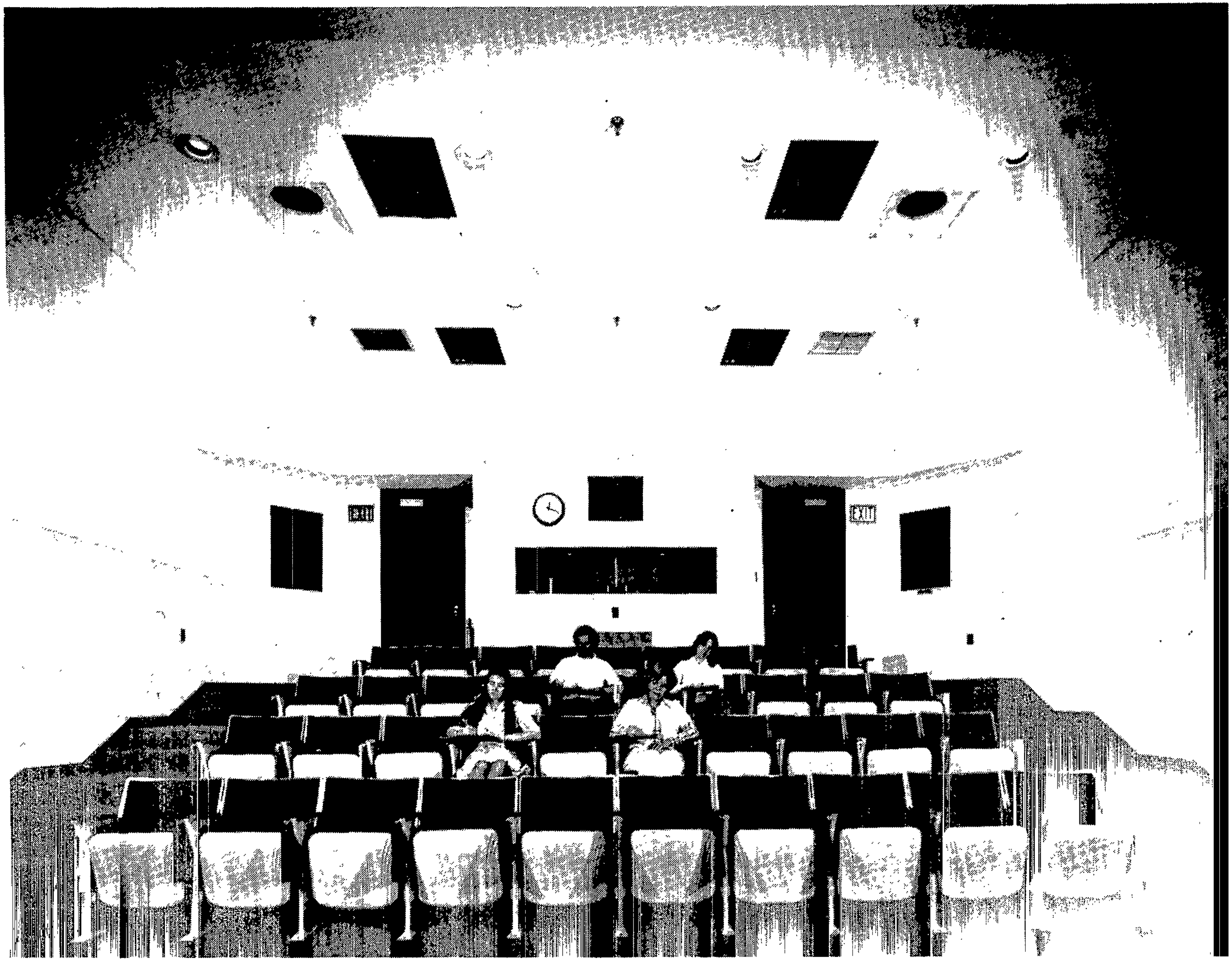


Figure 3.- Components of aircraft-noise adaptation model.



L-78-3713

Figure 4.- Exterior effects room of Langley Aircraft-Noise Reduction Laboratory.

L-79-101

Figure 5.- Psychophysics Laboratory of Columbia University.

Street-noise impact, L_{eq}		Aircraft-noise impact, NEF: Low (< 30)	Medium (30-40)	High (>40)
	Low (<57)	Sites 1 and 2	Sites 7 and 8	Sites 13 and 14
	Medium (57 - 61)	Sites 3 and 4	Sites 9 and 10	Sites 15 and 16
	High (61>)	Sites 5 and 6	Sites 11 and 12	Sites 17 and 18

Figure 6.- Experimental design for selection of sites.

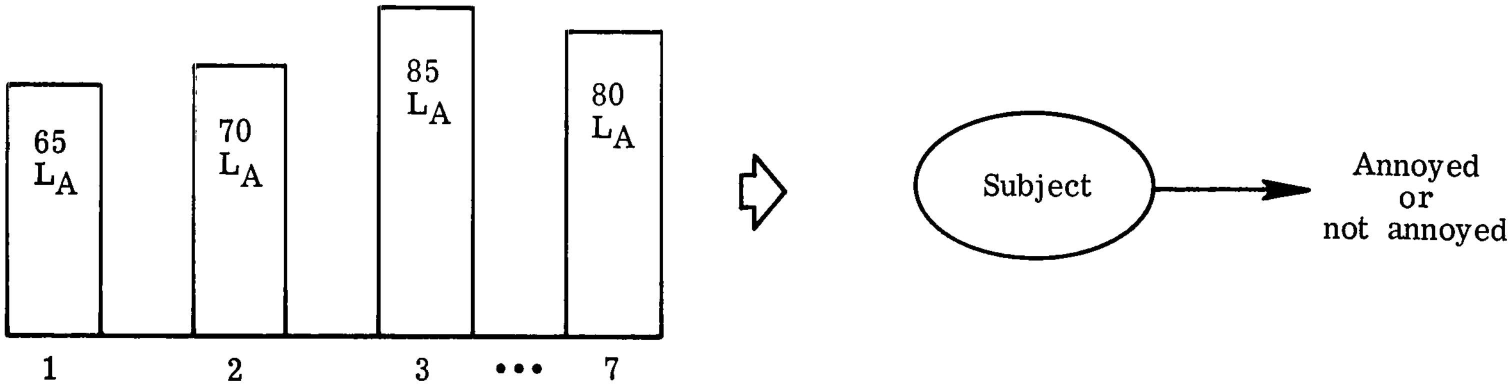


Figure 7.- Procedure for determining measured aircraft-noise adaptation level.

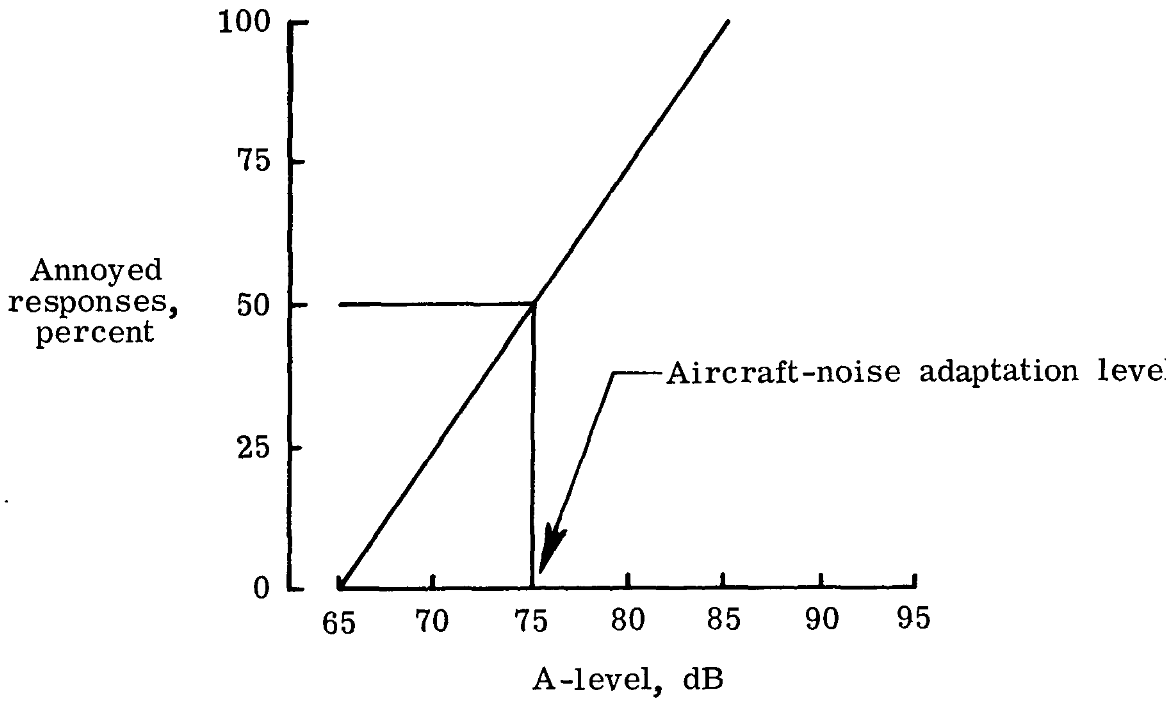


Figure 8.- Example of measured aircraft-noise adaptation level for one subject.

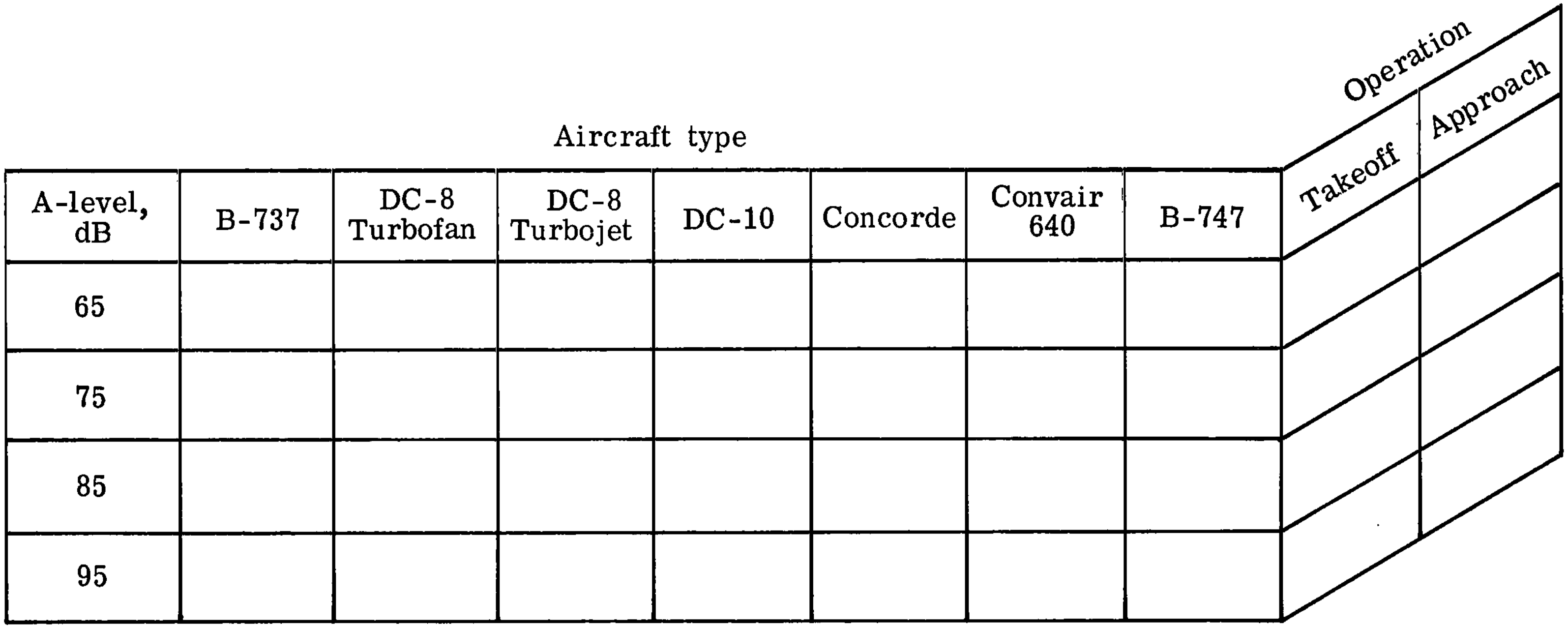


Figure 9.- Experimental design.

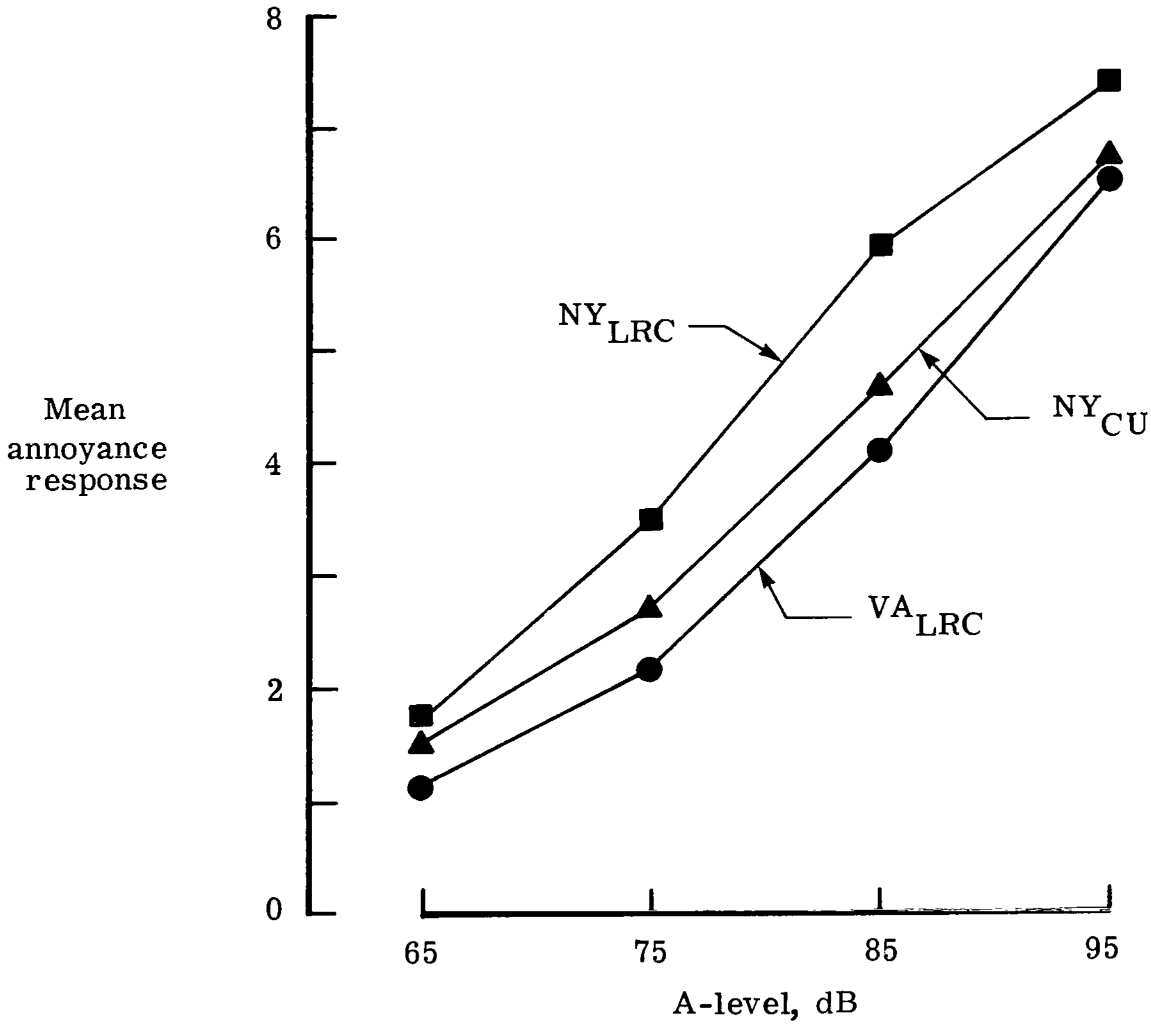


Figure 10.- Mean annoyance responses for the NY_{CU}, NY_{LRC}, and VA_{LRC} subject groups as a function of noise level.

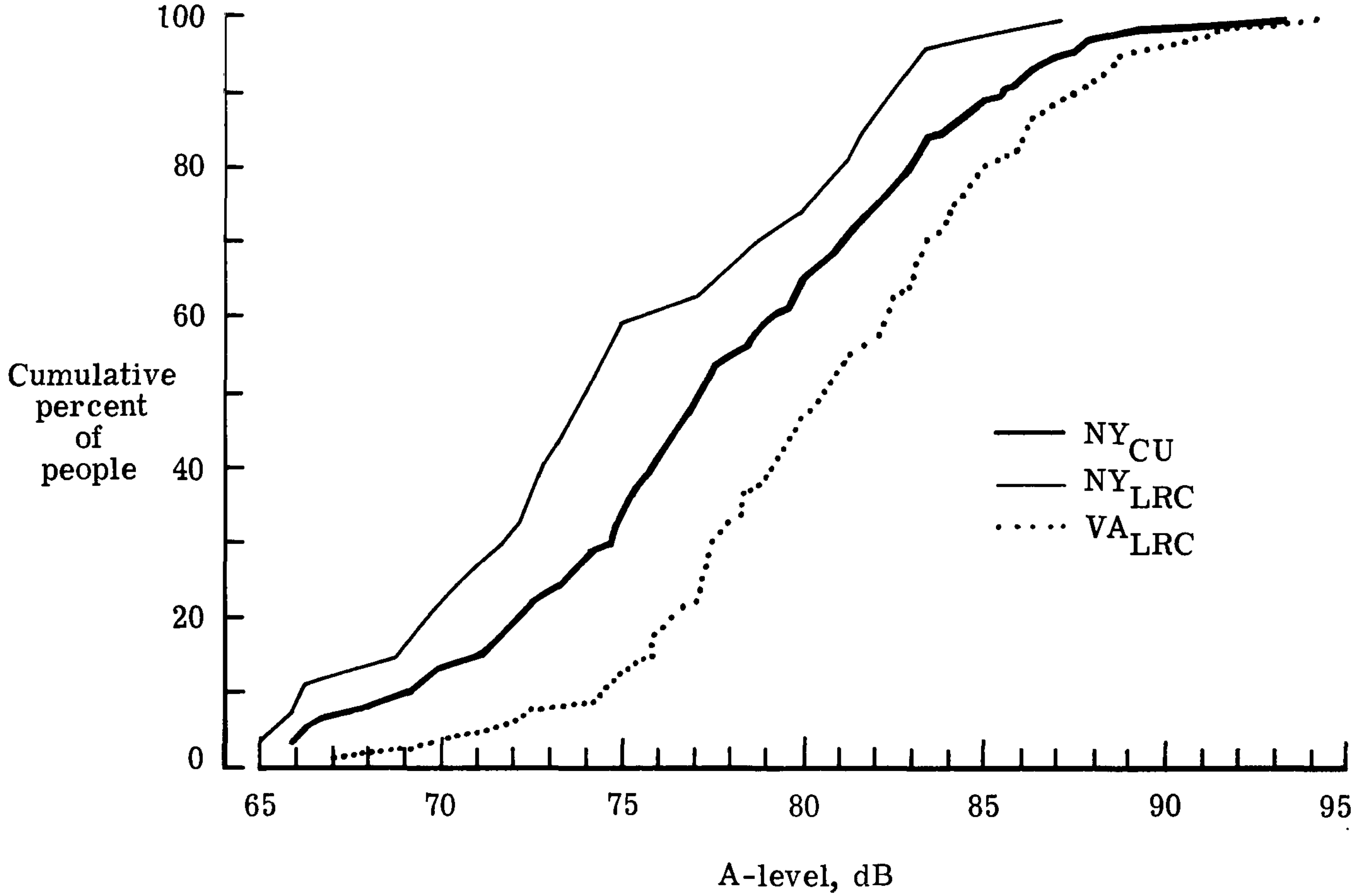


Figure 11.- Cumulative percent of subjects within each subject group who achieved aircraft-noise adaptation levels for a given noise level.

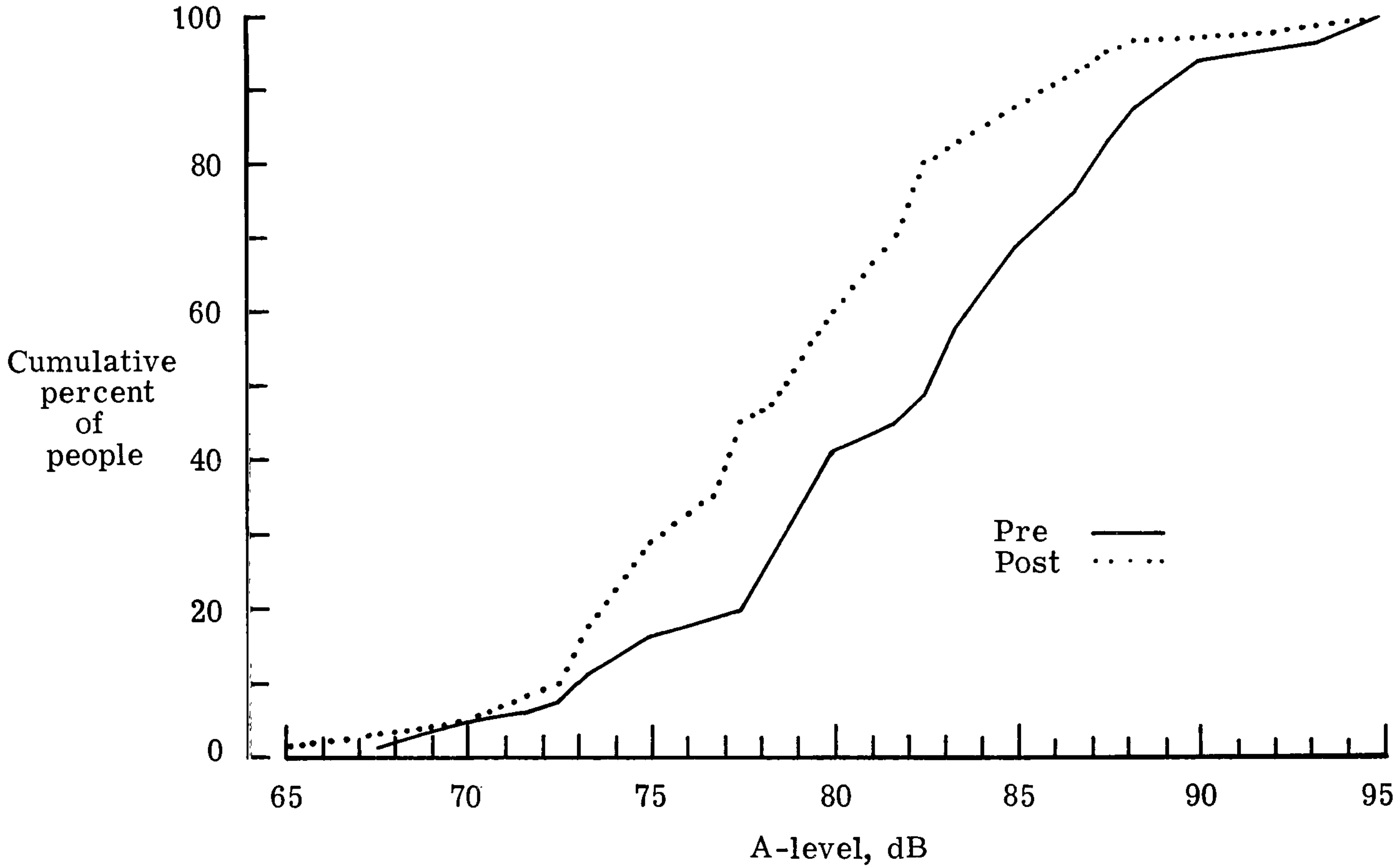


Figure 12.- Cumulative percent of VA_{LRC} subjects who achieved aircraft-noise adaptation levels as a function of noise level for prethreshold and postthreshold testing.

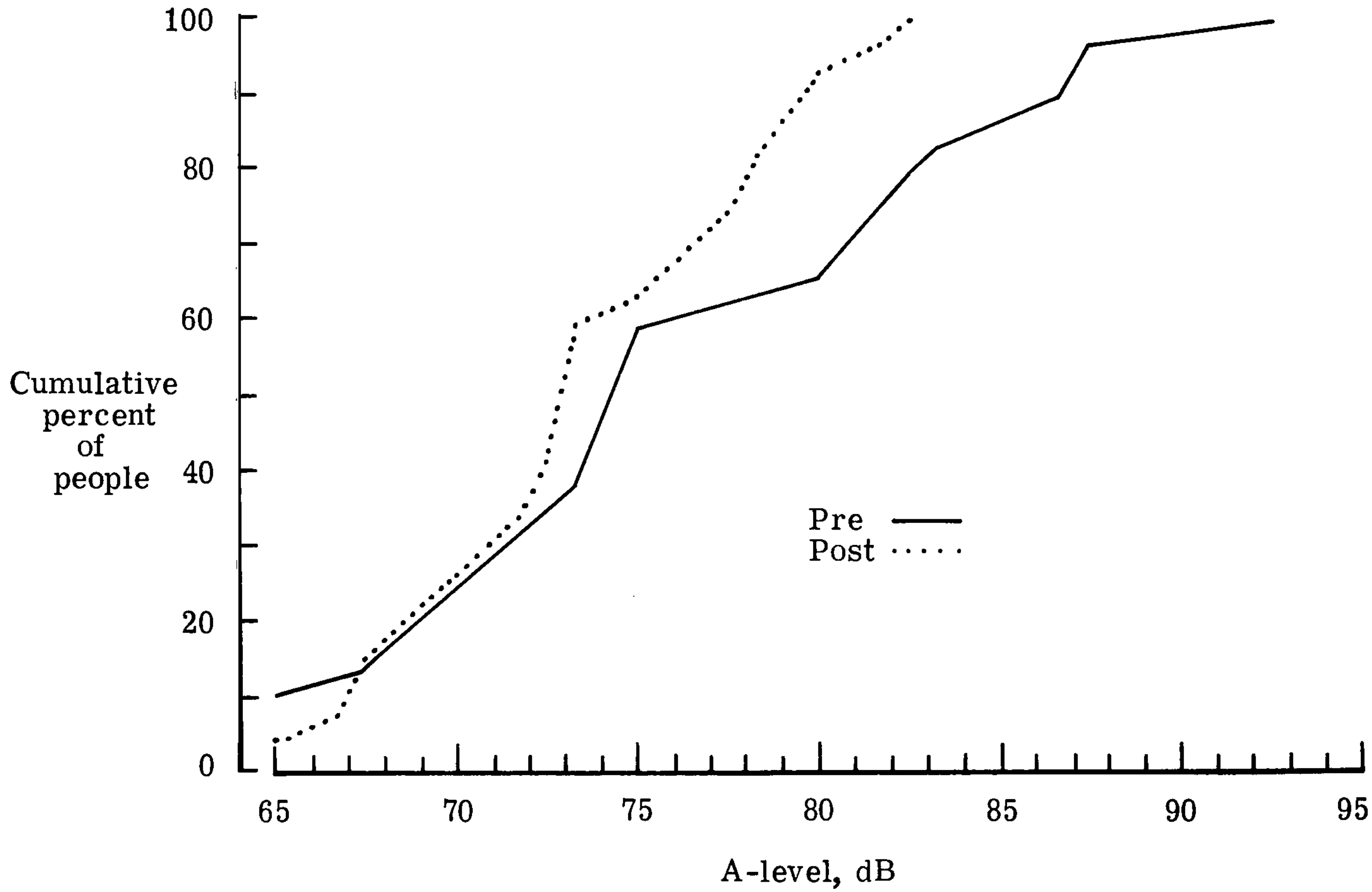


Figure 13.- Cumulative percent of NY_{LRC} subjects who achieved aircraft-noise adaptation levels as a function of noise level for prethreshold and postthreshold testing.

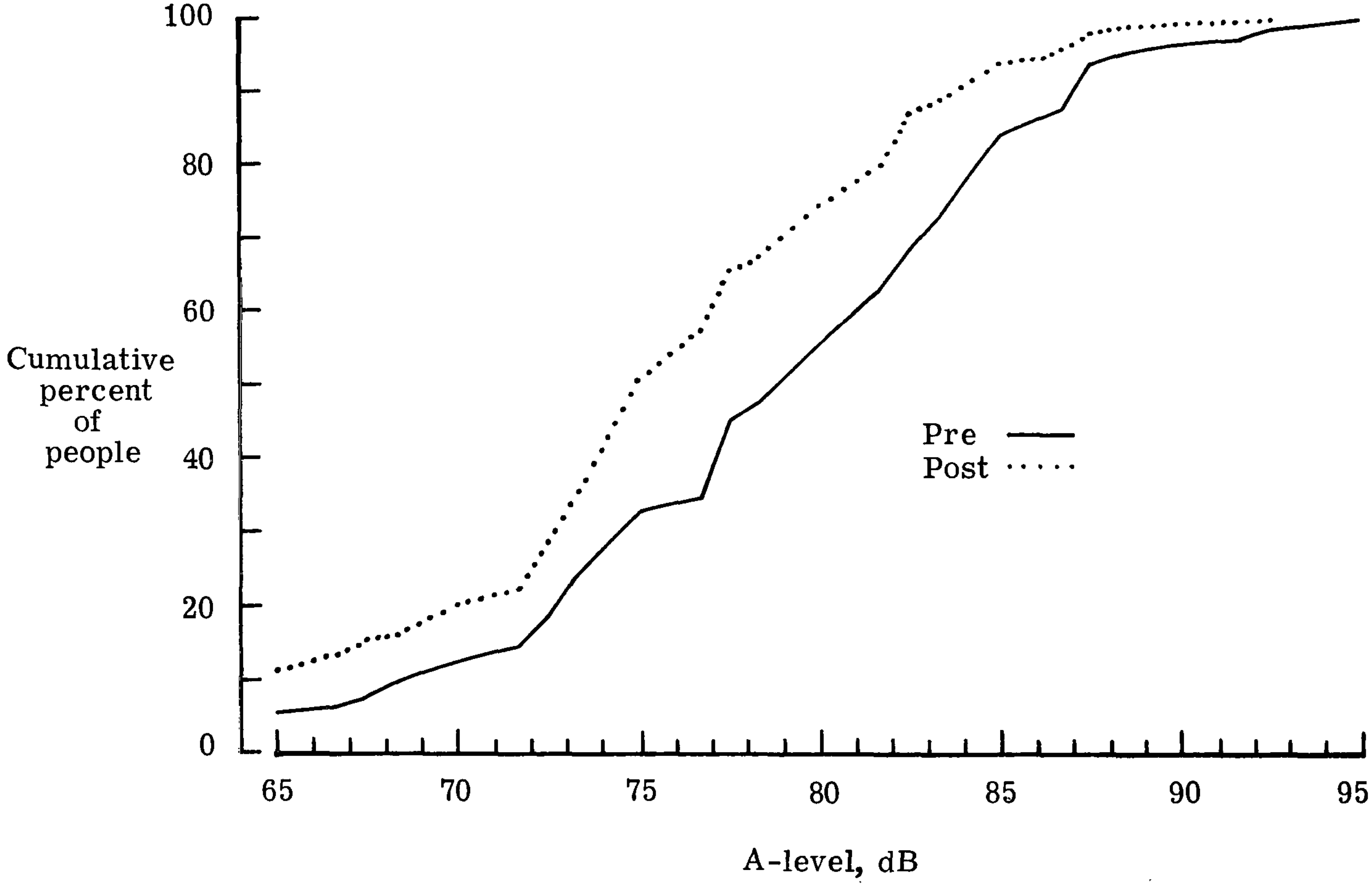


Figure 14.- Cumulative percent of NY_{CU} subjects who achieved aircraft-noise adaptation levels as a function of noise level for prethreshold and postthreshold testing.

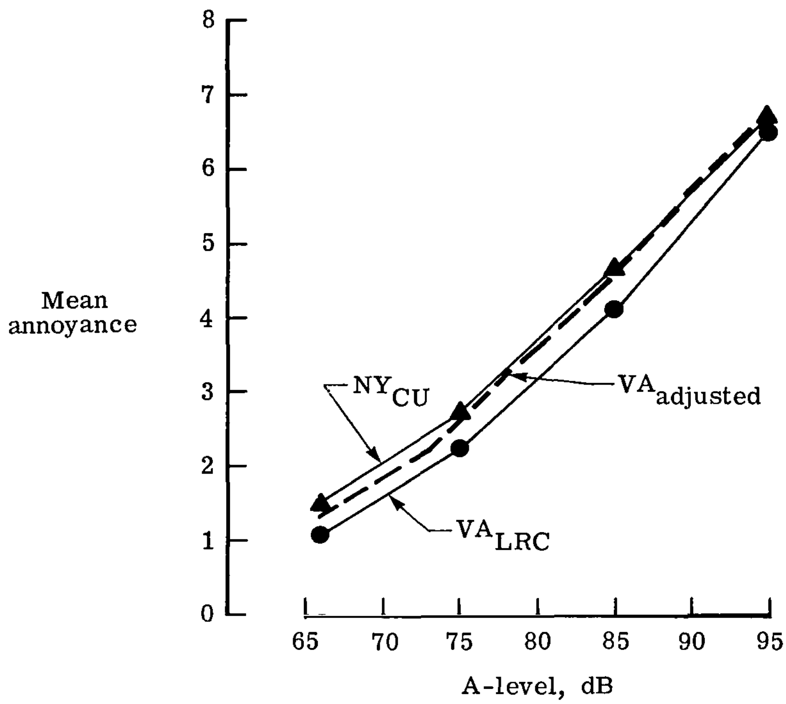


Figure 15.- Mean-annoyance responses for NY_{CU} and VA_{LRC} subject groups including VA_{LRC} adjusted responses.

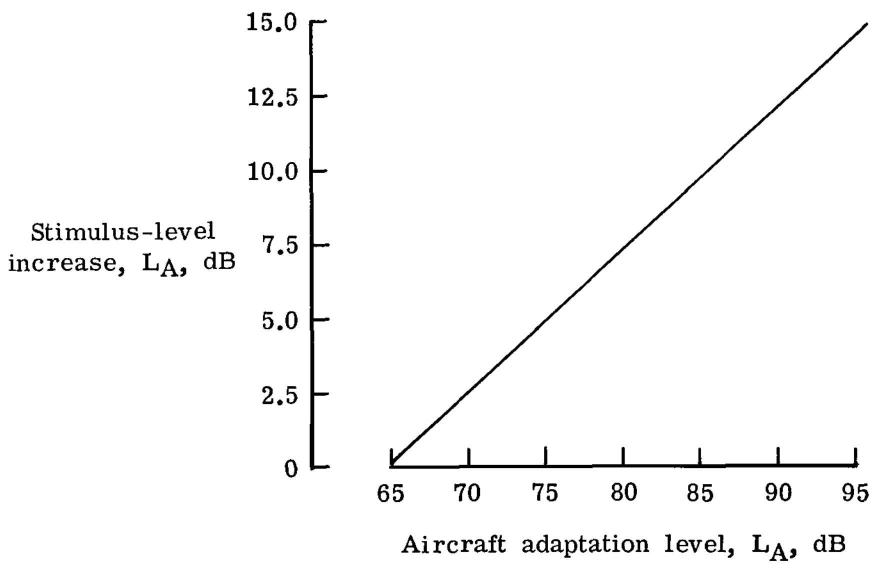


Figure 16.- Stimulus-level increases required for constant annoyance as a function of an individual's aircraft-noise adaptation level.

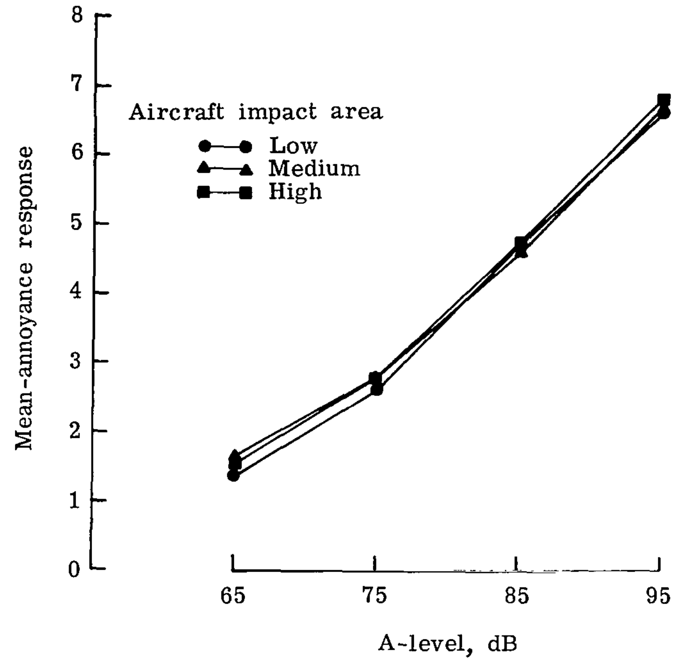


Figure 17.- Mean-annoyance response for residents of low, medium, and high aircraft impact areas as a function of noise level.

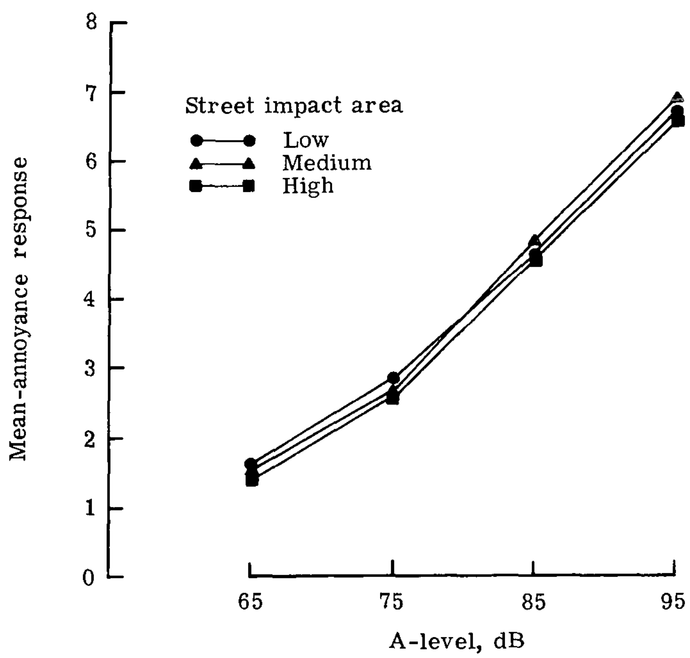


Figure 18.- Mean-annoyance response for residents of low, medium, and high street-noise areas as a function of noise level.

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TP-1335		

4. Title and Subtitle	5. Report Date
VARIABILITY OF ANNOYANCE RESPONSE DUE TO AIRCRAFT NOISE	March 1979
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Thomas K. Dempsey and Jimmy M. Cawthorn	L-12483
	10. Work Unit No.
9. Performing Organization Name and Address	505-09-13-11
NASA Langley Research Center Hampton, VA 23665	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Technical Paper
National Aeronautics and Space Administration Washington, DC 20546	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

An investigation was conducted to study the variability in the response of subjects participating in noise experiments. This paper presents a description of a model developed to include this variability which incorporates an "aircraft-noise adaptation level" or an annoyance calibration for each individual. The results indicate that the use of an aircraft-noise adaptation level improved prediction accuracy of annoyance responses (and simultaneously reduced response variation). Incorporation of a person's aircraft-noise adaptation level in these predictions significantly reduced the within-group variation and at the same time appeared to account for between-group variation. However, the aircraft-noise adaptation levels could not be predicted by either attitude-personality indices collected from each individual or aircraft-street noise impact information collected in the vicinity of a person's residence. Furthermore, for the present experiment no evidence was found to support the contention that the subject's annoyance varied as a function of the noise environment of the subject's residence.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Aircraft-noise adaptation Human response to aircraft noise Street-noise survey Attitude-personality variables	Unclassified - Unlimited Subject Category 71

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	74	$5.25

* For sale by the National Technical Information Service, Springfield, Virginia 22161

NASA-Langley, 1979